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Issued February 13, 1911.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 428.

TESTING FARM SEEDS IN THE HOME AND IN THE RURAL SCHOOL.

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WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., October 11, 1910.

SIR: I have the honor to transmit and to recommend for publication as a Farmers' Bulletin the accompanying manuscript, entitled "Testing Farm Seeds in the Home and in the Rural School," by Mr. F. H. Hillman, Assistant Botanist, which has been submitted for publication by Mr. E. Brown, Botanist in Charge of the Seed Laboratory.

Respectfully,

G. H. POWELL,
Acting Chief of Bureau.

HON. JAMES WILSON,
Secretary of Agriculture.

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B. P. I.–627.

TESTING FARM SEEDS IN THE HOME AND IN THE RURAL SCHOOL.

INTRODUCTION.

Progressive farmers who recognize the importance of better and more profitable crop production are becoming convinced that the quality of the seed used is worthy of careful attention.

The results of seed tests made at the Department of Agriculture and at the state experiment stations show that certain kinds of farm seeds in which there is an active trade and a strong competition are often seriously adulterated, the effect being that the farmer buying such seed gains a disappointing experience instead of a satisfactory crop. Again, the seed of certain farm crops is often mixed with seed of especially noxious weeds, necessitating labor and expense in preventing permanent injury to the farm. Seed may have a low germinating power due to age or to unfavorable conditions of development or of harvesting. Seed of clovers and of alfalfa found on the market sometimes comes from foreign regions possessing a less rigorous climate than that under which the seed would be grown in this country. For this reason such seed is undesirable. These results of tests made in the laboratory are fully corroborated by the experiences of farmers engaged in growing crops.

The popular agitation within recent years in the interest of better seed has brought about some change in trade conditions, but much room for improvement still remains. While a few States now have laws pertaining to poor seed, there is no Federal law preventing the importation of poor seed or its distribution by interstate traffic. In consequence of this, protection in seed buying is very largely a matter of business acumen on the part of the individual purchaser, which becomes very important when the purchaser is also the consumer.

In the matter of seed buying the best protection to the purchaser is believed to be self-protection based on the ability to judge the quality of the seed offered. This belief is supported by the fact that it is both possible and practicable for buyers or consumers of seeds to determine very accurately their quality.

The purpose of this bulletin is to encourage seed testing in the farm home and in the rural school by explaining the essential features of seed testing as it relates to farm seeds and by showing how satisfactory tests can be made by simple means. The expense involved is slight and, considering the little effort and time required, is thoroughly justified by the practical information to be gained. The writer's observation of the readiness with which beginners have qualified themselves for making such tests under instruction scarcely more favorable than that offered here, satisfies him of the absence of any valid reason why farmers should not protect themselves from the use of poor seed.

An important advantage of making tests at home is that the time required to get a report on a sample of seed sent to Washington or to an experiment station for test is saved. This obstacle removed, a practical examination or test will often be made, when if the seed must be sent away it will be bought untested. Furthermore, a purchaser's order from sample is much more likely to be filled from the seed actually represented by the sample if the delay in sending away for a test report is avoided.

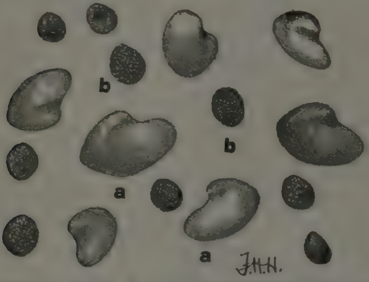

FIG. 1.—Seeds of clover dodder (**b**) and red clover (**a**), showing relative sizes. (Enlarged.)

Seed testing is admirably adapted for practical exercise work in rural schools giving instruction in elementary agriculture. It is easily carried on at any season of the year and requires but little outlay for apparatus or working material. If tests are made of seed of interest at the time in the homes of the pupils, the results may be of very practical service. A study of farm seeds and their impurities tends to interest pupils in crops and weeds and in their interrelation on the farm.

SEED TRADE CONDITIONS.

GENERAL STATEMENT.

Most of the undesirable conditions exhibited by seed which make seed testing necessary are the result of trade influences. The responsibility for these conditions doubtless rests fully as much with the mass of consumers who demand low-priced seed as with the dealers who cater to this demand. The trade has employed various means to meet the demand for low-priced seed. Large importations are made of the same kinds of seed which are produced in and are exported from this country. The imported seed can be sold cheaper than that which is exported. Grades of seed which are practically unsalable in Europe find a ready market here because the better American-grown seed is commonly considered too high priced. Various forms of seed adulteration have long been practiced, and seed ill adapted to our climatic conditions has often been sold. The results have been frequent failure of crops, an excessive cost of the actually good seed, and a wider distribution of many kinds of foreign weeds than by any other means. A general understanding of these conditions as they relate to particular kinds of seeds is helpful in making tests.

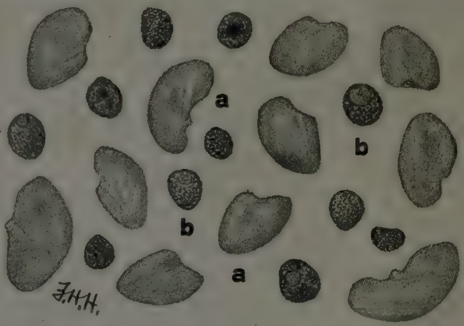

FIG. 2.—Seeds of clover dodder (**b**) and alfalfa (**a**), showing relative sizes. (Enlarged.)

APPLICATION TO KINDS OF SEEDS.

Red clover and alfalfa.—Seed of both red clover and alfalfa is imported, chiefly from Europe, in large quantities annually, and much of it is low in quality. Such low-grade seed is usually very weedy. The imported red clover seed is often a grade of small-seeded screenings which carries a class of weed seeds rarely found in a large-seeded grade of clover seed. Such low-grade seed carries seed of clover dodder in nearly every instance, while American-grown clover seed practically never carries this kind of dodder seed. (See fig. 1.) Shriveled alfalfa-seed screenings containing very little, if any, good seed are sometimes imported. Such material can serve only as an adulterant. Cheap imported alfalfa seed usually carries clover dodder while American seed is free from it. (See fig. 2.) Again, buckhorn, wild carrot, and wild chicory seeds are nearly always found in the cheap alfalfa seed from Europe, while they do not appear in most lots of American seed.

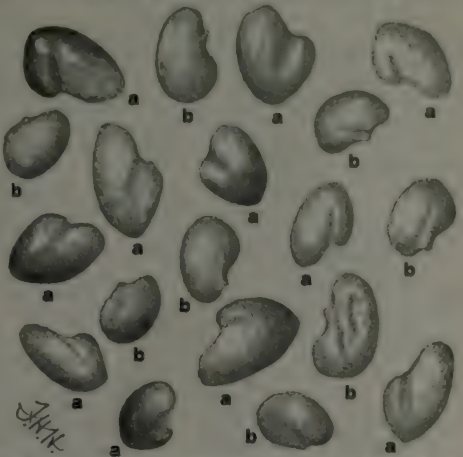

FIG. 3.—Mixture of seeds of red clover (a) and yellow trefoil (b). The clover seeds are more or less triangular, those of trefoil oval, and usually with a distinct projection beside the scar notch. (Enlarged.)

Both red clover seed and alfalfa seed are subject to adulteration with yellow trefoil seed. (See figs. 3 and 4.) Alfalfa seed, furthermore, is adulterated with sweet clover seed (fig. 5) and with seed of the bur clovers. (See fig. 6.) Seed of red clover, alfalfa, and crimson clover from the warmer parts of Europe is from a tenderer strain of plants than is demanded in most parts of this country. Experiments have shown that, as a rule, such seed can not compete in crop production with domestic seed.

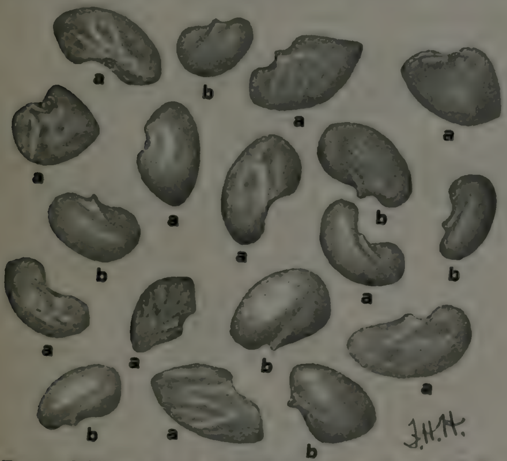

FIG. 4.—Mixture of seeds of alfalfa (a) and yellow trefoil (b). Alfalfa seeds are more or less kidney-shaped or angular, while those of trefoil are more uniformly oval and have the small projection at the scar more commonly evident. (Enlarged.)

Considerable red clover seed has been imported from Chile within recent years. This seed is the best appearing clover seed in our market, and authentic reports show that it has proved productive in various localities extending from Canada nearly to the Gulf States.

Nearly every lot of this seed that has come under our observation, however, has been badly infested with an unusually destructive strain of field dodder seed (fig. 7).

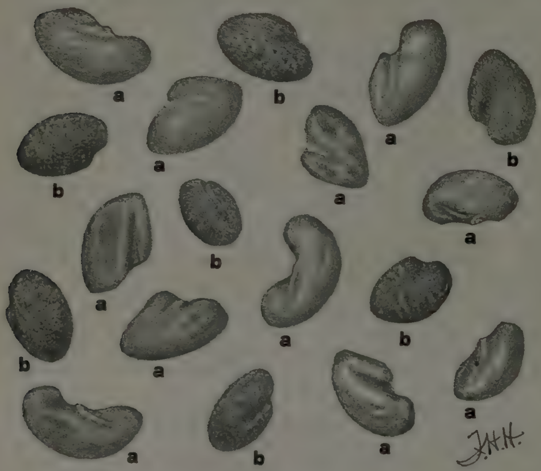

Fig. 5.—Mixture of seeds of alfalfa (**a**) and sweet clover (**b**). The elliptical form of the sweet clover seeds, which have the scar notch near one end, together with their uneven surfaces, serves to distinguish them from the more nearly kidney-shaped and smoother alfalfa seeds. (Enlarged.)

Alsike clover.—Seed of alsike clover is produced in the Northern States, but much of that in the market is imported from Canada. Very little is imported from Europe. Canadian seed, and doubtless some of that produced in the United States, often contains much Canada thistle seed — more, indeed, than is found in any other kind of farm seed. Yellow trefoil seed commonly appears in alsike seed, sometimes to the extent of severe adulteration. Low-grade, weedy, and shriveled screenings are sometimes used as an adulterant. (See fig. 8.) Several of the commoner kinds of weed seeds found in alsike clover seed are very detrimental. Some lots of alsike seed consist largely of timothy, which amounts to an adulterant if the mixture is sold at the price of pure alsike seed. This mixture is poor seed to sow if alsike seed production is contemplated; the two crops ripen together and their seed can not be wholly separated.

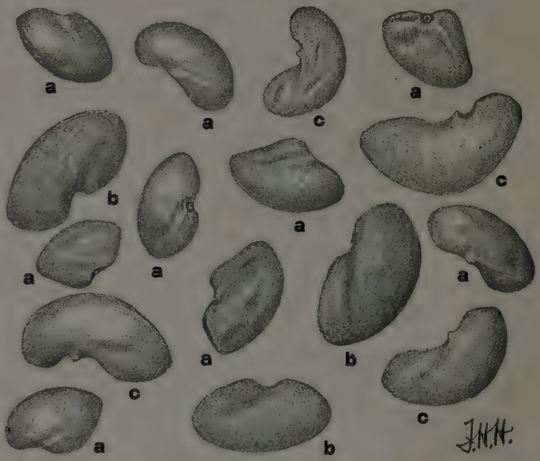

Fig. 6.—Mixture of seeds of alfalfa (**a**), toothed bur clover (**b**), and spotted bur clover (**c**). Note the larger size of the bur clover seeds, also the kidney shape of the spotted bur clover seeds, which have the scar near the smaller end. (Enlarged.)

Old stocks of seed of the clovers and of alfalfa having low vitality are often mixed with new seed. Such seed is sometimes oiled and rubbed to give it the appearance of freshness.

Grass seeds.—The seeds of grasses are subject to various conditions tending to reduce their quality. Adulteration with old seed or chaff of the same kind or with the very similar appearing seeds of other kinds is often practiced and readily escapes detection by both retail dealers and consumers. Accidental misbranding of grass seed in the trade is doubtless not uncommon.

Kentucky bluegrass seed is often adulterated with the similar Canada bluegrass seed or seed of the latter is substituted for the former. (See fig. 9.) Again, Kentucky bluegrass seed often has low germinating power, owing to improper methods employed in curing, and it is commonly very chaffy.

Orchard grass seed is adulterated with seed of meadow fescue, English rye-grass, or with both. (See fig. 10.)

Seed of meadow fescue, or English bluegrass, is adulterated with seed of the perennial, or English, rye-grass and with orchard grass chaff. (See fig. 10.)

Awnless (or Hungarian) brome-grass (*Bromus inermis*) seed is adulterated with meadow fescue and English rye-grass seeds and with chess, or cheat. (See fig. 11.) The latter has even passed in the trade as Hungarian brome seed.

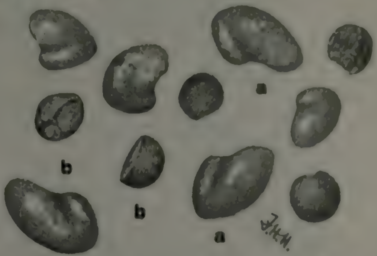

FIG. 7.—Seeds of field dodder (**b**) and red clover (**a**), showing relative sizes. (Enlarged.)

Redtop seed appears in the market in three grades, "recleaned" (or "solid"), "unhulled," and "chaff" redtop. The latter is very misleading, since it sometimes contains practically no good seed. The recleaned grade sometimes contains considerable timothy, which is inexcusable unless sold as mixed redtop and timothy.

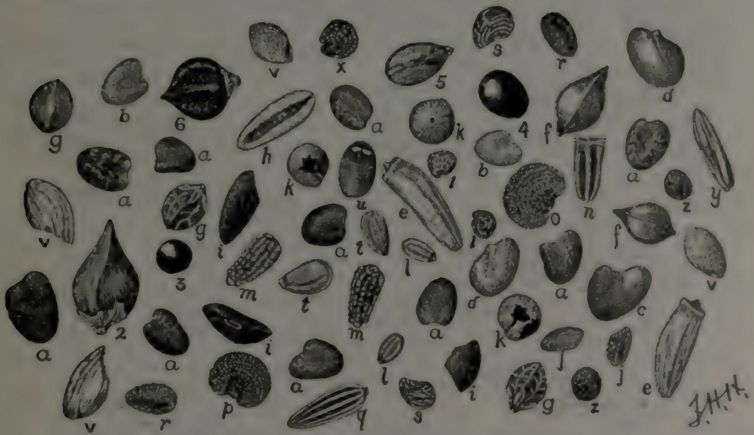

FIG. 8.—Mixture of weed seeds commonly found in low-grade alsike clover seed: **a**, Alsike clover; **b**, white clover; **c**, red clover; **d**, yellow trefoil; **e**, Canada thistle; **f**, dock; **g**, sorrel; **h**, buckhorn; **i**, rat-tail plantain; **k**, lamb's-quarters; **l**, shepherd's-purse; **m**, mayweed; **n**, scentless camomile; **o**, white campion; **p**, night-flowering catchfly; **q**, oxeye daisy; **r**, small-fruited false flax; **s**, cinquefoil; **t**, two kinds of peppergrass; **u**, catmint; **v**, timothy; **x**, chickweed; **y**, Canada bluegrass; **z**, clover dodder; **1**, mouse-ear chickweed; **2**, knot-grass; **3**, tumbling amaranth; **4**, rough amaranth; **5**, healall; **6**, lady's-thumb. (Enlarged.)

Rape, vetch, and flax.—Winter rape seed is liable to contain seed of the summer rape (bird rape), an annual variety of rape not adapted to the forage purposes of the winter rape. Seed of either winter rape or summer rape may contain the seed of various wild mustards, especially that of English mustard, or wild charlock. (See fig. 17, t.)

Winter (or hairy) vetch seed often contains seed of various varieties of spring vetch, from which it should be free.

Considerable flax seed is imported from Russia mixed with many impurities, including seed of the flax dodder, a kind of dodder particularly destructive to flax. (See fig. 12.) Seed from certain regions of production in this country is free from this dodder, false flax seed, and other impurities.

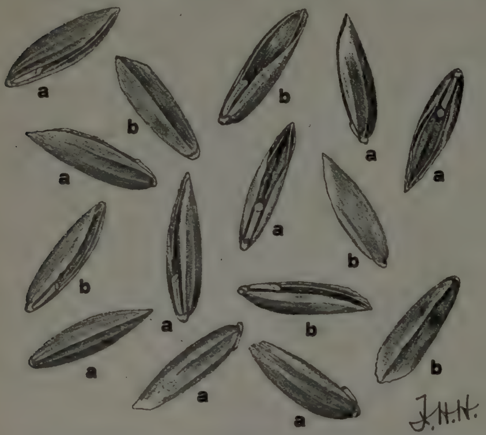

FIG. 9.—Mixture of seeds of Kentucky bluegrass (**a**) and Canada bluegrass (**b**). The Kentucky bluegrass seeds are broadest at the center, pointed, and have a distinct ridge on each side. Canada bluegrass seeds are mostly broadest near one end, blunt, and smooth on the sides. (Enlarged.)

APPRECIATION OF GOOD SEED NECESSARY.

These and other conditions of the seed trade operating against the use of the best seed have long prevailed in this country. They are likely to continue, largely irrespective of laws to the contrary, until consumers generally come to appreciate and accept only good seed. Consumers will need to know good seed from poor and to understand that the legitimate price of good seed is actually lower than the corresponding price of poor seed which costs relatively more to market, although the original cost to the dealer may be lower than that of high-grade seed.

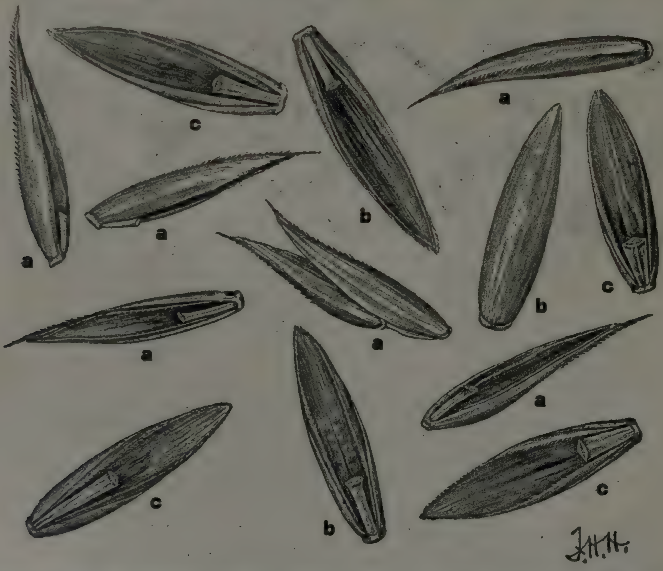

FIG. 10.—Mixture of seeds of orchard grass (**a**), meadow fescue (**b**), and English rye-grass (**c**). The orchard grass seeds are distinguished from the others by their slender, curved form. The meadow fescue and rye-grass seeds are distinguished by the difference in the section of the seed-cluster axis (rachilla segment) which each bears. (Enlarged.)

PURPOSE OF SEED TESTS.

The purpose of making tests of farm seed is to detect the undesirable conditions affecting the seed which have been referred to in preceding paragraphs. Such tests should be made early enough in the season to allow ample time to obtain other samples or to buy additional seed if the tests lead merely to providing for foreign matter by sowing a larger quantity of seed.

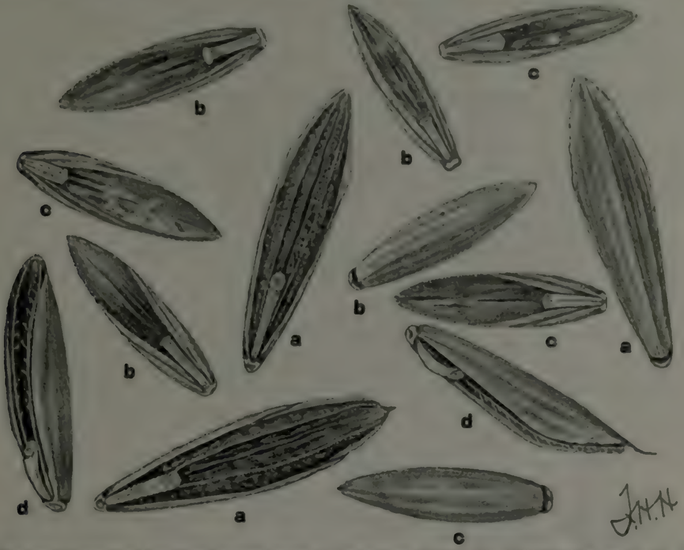

FIG. 11.—Mixture of seeds of awnless brome-grass (**a**), meadow fescue (**b**), English rye-grass (**c**), and chess, or cheat (**d**). The brome-grass seeds are distinguished by their greater length and flattened form. The seeds of chess (**d**) are somewhat cylindrical, due to being folded lengthwise. They are thus thicker than the awnless brome-grass seed and sometimes are awned. (Enlarged.)

The seed of most of the farm crops can be recognized with certainty under careful examination as to its particular kind. Seed of different varieties of a kind as a rule can not be distinguished in this way. For example, red clover seed can be distinguished from other seeds, but the medium and mammoth varieties of red clover can not be distinguished by their seeds. Seeds of varieties of individual kinds of plants usually must be grown to insure varietal determination. This is not a part of the usual seed test.

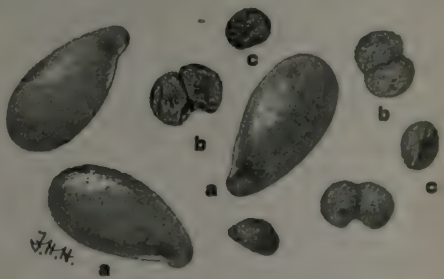

FIG. 12.—Seeds of flax dodder (**b** double, **c** single) and of flax (**a**), showing relative sizes. (Enlarged.)

The first object of the test, excepting with respect to varieties, is to find out if the seed is true to name.

The seed of certain farm crops is rarely free from all impurities. Miscellaneous impurities may appear or some one kind of foreign seed may be present as an adulterant. Old seed of the same kind as the crop seed may constitute an adulterant, a fact which becomes apparent in the germination test.

A second object of the test is to show if the seed has been intentionally adulterated.

The miscellaneous impurities of seeds are classified (1) as inert material incapable of growing, and (2) as foreign seed which may be capable of growing and producing plants.

A third object of the test is to show the relative proportions of comparatively harmless inert material and of possibly noxious foreign seed in the sample.

The foreign seeds in a sample, consisting usually of various kinds of weed seeds, may not amount to much in quantity, but their noxious character may make them very important.

A fourth object of the test is to disclose the presence of especially noxious weed seeds, as dodder, dock, thistle, etc.

A fifth object of the test of seeds in which the region of production is a matter of importance is to show, if possible, by the nature of its impurities, the probable source of the seed or to show if it is a mixture of domestic and foreign-grown seed.

A sixth object is found in the germination test, showing how much of the seed is capable of growing under favorable conditions. The energy with which the seed sprouts is to be considered. With new clover and alfalfa seed the amount of "hard seed," or seed which absorbs moisture slowly and therefore sprouts tardily, is to be noted and allowed for in using the seed.

The objects thus enumerated relate particularly to the seed of miscellaneous forage crops. Interest in the seed of the cereals and corn centers chiefly in the germination test with respect to the extent and character of the sprouting.

SEEDS ESPECIALLY NEEDING TO BE TESTED.

While all kinds of farm seeds may be subjected to a test of one kind or another, the seeds of the crops in most general use and which it is especially desirable to have tested represent the true clovers (as red, alsike, and crimson), alfalfa, certain grasses (as timothy, orchard grass, fescue grass, bluegrass, brome-grass, and the millets), cereals, rape, flax, vetch, and corn. The reason for this selection is that much of the seed of the crops enumerated, except cereals and corn, is imported, and widely variable grades are on the market. The magnitude of the trade in this class of seeds shows that the majority of farmers do not depend on domestic production for the seed they use. It is probable that the prevalence of foreign-grown seed in the market is not generally recognized by farmers in localities where locally grown seed is ordinarily used.

EASE OF MAKING PRACTICAL TESTS.

Seed tests sufficiently accurate to answer all practical purposes can be made by a beginner with a little practice. Certain time-consuming and exacting features of detail in making official tests at Washington or at an experiment station are often unnecessary in making tests for the facts of most practical importance.

By providing the apparatus and following the directions for making tests suggested in the following pages and by using the illustrations in comparing seeds of different kinds one can soon become sufficiently expert to feel reasonable confidence in his ability to avoid errors of importance.

The younger members of the home circle should find such work comparatively easy to accomplish and interesting as well. The testing of locally grown seed would be assisted by the possession of a correctly named set of the seeds of crops and of weeds prevailing in the vicinity.

When the work is done in the school, samples of seed of local interest and obtainable at the homes of the pupils may be used. This tends to impress the pupils (and their parents as well) with the immediate utility of the work. If suitable seed is not obtainable locally, samples representing different grades can be obtained from dealers. The boys can make the balance here described. Several balances may be made and their efficiency compared. The successful making of such apparatus has a distinct educational value of its own. One pupil may be authorized to procure the magnifiers required; another may be delegated to provide one or more plate germinators or to make the corn-germinating box. Germination tests made in cloth, paper, sand, and soil may be compared, showing the effect of surrounding conditions. Such actual practice makes the pupil do and think and fits him to master corresponding but more complex problems later.

APPARATUS USED IN MAKING TESTS.

The need of apparatus.—Only such apparatus is needed in making practical seed tests as enables one to use a weighed quantity of seed from the sample, to separate the pure seed from the foreign seeds and other impurities, to distinguish the character of the foreign seeds, and to make the germination test.

It is important to use a weighed quantity of seed in the test, because only in this way can one determine the relative quantity or percentage of pure seed as compared with the quantity of the impurities. This requires a balance sufficiently sensitive to be moved by a small weight, such as that of a few clover seeds. This sensitiveness is necessary, because only a small sample of seed can be used in the test. A large sample would require too much time and labor. For this reason only small samples are used in making official tests of seeds.

The absence heretofore of a readily available, effective balance suited to this work doubtless has been the chief bar to the popularizing of farm and rural-school seed testing. Expensive chemical balances are used in making official tests, and the cheaper balances on the market cost from $10 to $35—an expense beyond the reach of the mass of consumers who should profit by practical seed tests.

The balance.—A simple, efficient balance can be made by any boy or girl at all familiar with the use of a few common tools. The general construction is clearly shown in figure 13, to which the letters used in the following description refer:

The balance consists of a hexagonal, or six-sided, pencil (**a**) notched as nearly as possible in the center and halfway through the lead. Make a rather wide V-shaped notch. Half of a similar pencil is notched likewise at its center, care being taken that the angle at the apex or "bottom" of the notch is made narrow, straight, and smooth. At this point the balance rests on the small blade of a knife, as shown in the figure. The blade must not bind and the pencils must swing on its edge with the least possible friction. The two pencils are firmly rubber-banded together so that the two notches form an opening nearly square between the pencils. Near each end of the long pencil and on its notched side make a shallow hole (c) by boring into the wood with a hard pencil having a smooth, slightly blunt point. In order that the balance may operate properly the apex of the notch in the short pencil—that is, the point which rests on the knife-edge—must be exactly midway between the holes in the ends of the long pencil. Slide the short pencil along the other till it is in proper position, then with the point of the knife-blade cut a mark (d) common to both pencils on the line where they touch. The rubber bands should prevent the pencils from slipping when in use, but the mark

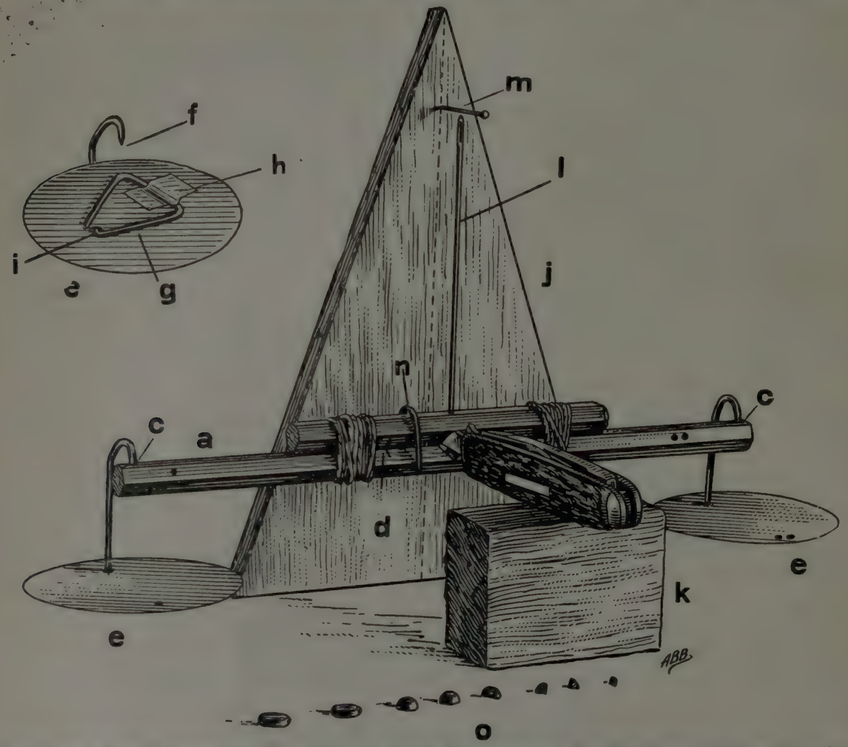

Fig. 13.—A simple balance used in making the purity test of seeds: **a**, Six-sided pencil, full length, and a half-length pencil bound to the long pencil by rubber bands; **c**, shallow holes near the ends of the long pencil; **d**, reference mark common to both pencils at a convenient point on the line where they meet; **e**, trays for holding the seed and the weights, the upper one showing the under side; **f**, bluntly pointed end of the wire adapted to fit loosely in one of the holes (**c**); **g**, wire bent beneath the tray to hold it in position; **h**, piece of gummed paper holding the wire to the tray; **i**, hole at proper distance from the center of the tray where the wire pierces it; **j**, thin piece of board holding the parts of the balance in position; **k**, the block of wood holding the knife handle at proper level; **l**, darning needle serving as a pointer as the pencils oscillate in weighing; **m**, pin marking the position of the head of the needle when the trays are properly balanced before and at the close of weighing; **n**, "rider," or wire staple, so placed as to balance the trays when empty; **o**, series of selected BB shots used as weights; whole ones are flattened to prevent rolling; others are cut into halves, quarters, eighths, and sixteenths, and selected with reference to the equality of their weights.

will show if they do slip. Two similar trays (**e**) are hung from the ends of the long pencil. They consist of circular pieces of stiffish cardboard about 2 inches in diameter suspended by means of wires curved in fishhook form, the points of the hooks resting within the holes (**c**) previously made in the pencil ends. The points of the hooks (**f**) are bluntly and smoothly pointed, so as not to bind in the holes. Beneath the trays the wires (**g**) are bent to hold the trays in level position, and are held to the tray by pieces of gummed paper (**h**). The illustration shows the trays as flat pieces of cardboard. It is better to cut the trays from the edge to the center, then lap the two cut edges and glue them fast, thus making a shallow dish. The wire (**g**) beneath the tray is then preferably bent in circular form. Balancing the tray hook on the finger shows the proper bending of the wire where it pierces the cardboard (**i**) to make the tray hang level. A triangular piece of thin board (**j**), as a cigar-box cover, serves to hold the knife blade in position. A block (**k**) holds the knife handle. The knife is set high enough to permit the trays to hang about one-half inch above the surface on which the balance rests. For the purpose of showing slight movements of the balance in exact weighing, a darning needle (**l**) is set in the top of the short pencil directly over the knife-edge and at right angles to the pencil. A pin (**m**) is placed in the board directly over the point where the knife point pierces it and just above the end of the needle. When the device is properly balanced the end of the needle will stand at rest directly under the pin. It probably will not balance until a staple of wire (**n**) is placed over the pencils in proper position on one side of the knife blade or on the other as a counterweight. This completes the construction, and when properly mounted the balance should oscillate freely by the slightest touch. As the trays are likely to be interchanged in use it is advisable to mark each, placing corresponding marks on the ends of the pencil at which the trays preferably belong.

In making seed tests we may use common BB shots (whole and fractional) for weights. This is because we wish to know only the comparative weights of the pure seed and of the foreign seed and other impurities in the sample. Thus if we test an amount of seed, balancing ten shots, and find that the weed seeds it contains just balance one shot, it is evident that one-tenth of the original seed, or 10 per cent, consists of impurities. In other words, 90 per cent (or 90 pounds of each 100 pounds) of the original seed is pure seed. In using a balance so sensitive as the one described a single BB shot is too heavy for use as the lightest weight. We need a weight to be balanced by only a few clover seeds at most. Very small shot is troublesome to handle and count, so we use the larger BB shots, flattening the whole ones to prevent them from rolling, and cutting some into halves, quarters, eighths, and sixteenths. By careful selection according to weight a fairly uniform series (**o**) of whole and fractional shots can be provided. Now, the weight of one-sixteenth shot is 1 per cent of the weight of 6¼ shots, because 6¼ equals 100 ÷ 16. So if we test a sample of seed balancing 6¼ shots any impurity balancing the $\frac{1}{16}$-shot weight represents 1 per cent of the sample tested. If the sample is twice as heavy, balancing 12½ shots, the $\frac{1}{16}$-shot weight represents one-half of 1 per cent of the whole.

It is evident, therefore, that the means described enables one to determine the quantity of pure seed or of impurities in a sample to within 1 per cent, or even one-half of 1 per cent of the true quantity. This is sufficiently close for the practical seed testing under discussion.

The forceps.—A pair of forceps is very useful in picking up the small weights used with the balance, also individual seeds. Suitable forceps may be made of two thin pieces of hickory wood separated by a piece of wood to which one end of each piece is fastened. The free ends are flattened and pointed. A piece of spring wire bent in U shape and having flattened and pointed ends serves very well as forceps.

The magnifiers.—After the seed to be tested has been properly weighed it is to be separated into pure seed and foreign seed or other impurities. This requires a magnifier. Very coarse seed—such as that of wheat, oats, flax, etc.—can usually be examined by the aid of an ordinary reading glass, which is to be found in many homes or can be bought at a cost of $1 to $2. Clover seed, alfalfa seed, and the grass seeds require a magnifier of higher power. A very satisfactory magnifier of this kind is the tripod magnifier, shown in figure 14. With it one can distinguish all the kinds of crop seeds and practically all the different kinds of adulterants and weed seeds. This magnifier is sold by opticians, stationers, and druggists generally throughout the country at prices ranging from 50 to 75 cents.

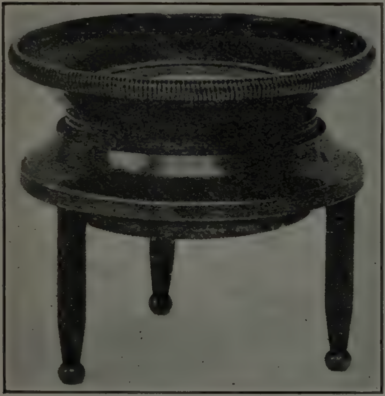
FIG. 14.—Magnifying glass.

The paper tray.—Seed is examined best over white paper, and in order to prevent the loss of seed from a weighed sample a paper tray is useful. Such a tray is made from stiffish white paper, as a sheet of heavy letter paper. The edges of the sheet on all four sides should be folded over, making a rim one-fourth inch wide. Folding the edges over the straight angular edge of some convenient object largely prevents the paper from warping and makes it easier to use. Cutting off one corner permits the seed to be poured easily from the tray.

The germinator.—Figure 15, showing the simple plate germinator, is self-explanatory. Either blotting paper or cloth may be used to receive the seed. Clean sand may be preferable for some kinds of seed. A germinator of this description is most useful in testing forage-crop seeds or seeds of cereals. In testing corn the sand-box method, described in Farmers' Bulletin 409, entitled "School Lessons on Corn," is very satisfactory, or the cloth method may be employed. This method makes use of a box of convenient size, say 20 inches square, interior dimensions, and 2 or 3 inches deep. The seed is placed on white cloth, preferably Canton flannel, which is cross marked on the smooth side with distinct pencil lines in 2-inch squares. The required moisture is held by extra thicknesses of cloth or by clean sand beneath the cloth, forming a layer about an inch thick over the bottom of the box. If Canton flannel (which comes 27 inches wide) is to be used instead of sand, the box may be made narrower than suggested, say 12 inches, thus allowing for folding the cloth and for shrinkage.

DISTINGUISHING CHARACTERS OF SEEDS.

Safeguarding against deception.—One of the first steps in testing seeds of the forage crops is to determine if the sample is true to name, and it is necessary that these kinds of seeds be recognized with certainty. While most farmers, as a rule, can recognize red clover seed, for example, when they see it in bulk, it is not so certain that they would recognize individual seeds of red clover under all conditions, as one must in making tests of this seed. Again, alfalfa seed in bulk is recognized by most farmers, because they contrast it with red, alsike, and white clover seed with which they are familiar as these seeds appear in bulk. It is a question, however, if the average farmer would detect yellow trefoil seed in bulk or sweet clover seed in bulk were it not for the characteristic odor of the latter. Bur clover seed would be found even more deceiving.

The chances for deception are even greater with grass seeds than with clover seeds, because of the striking similarity between the seeds of different kinds when seen in bulk. This similarity and the fact that mere casual examination is usually given seed by purchasers makes adulteration, substitution, and misbranding possible.

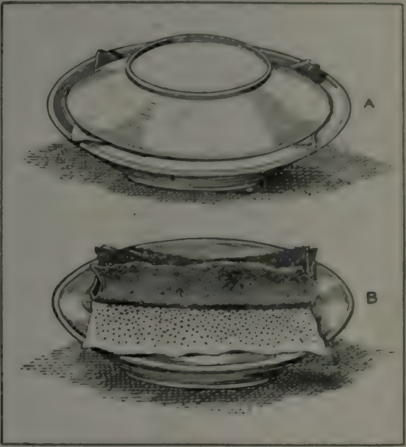

FIG. 15.—Homemade seed germinator: A, Closed; B, open.

The remedy lies in familiarity with the distinguishing characters of individual seeds. By comparing seeds of the several kinds with the illustrations and descriptions here given one should be able to distinguish them individually without much difficulty.

Leguminous seeds.—All the true clovers (as red, alsike, white, and crimson), alfalfa, the vetches, trefoil, sweet clover, and bur clover, produce seeds in a pod which (except in trefoil, sweet clover, and bur clover) opens at maturity. In red clover, trefoil, and sweet clover a single seed is produced in each pod. Consequently, the seeds of each kind are very similar in form. (See figs. 22, 23, and 27.) Alfalfa and bur clover produce several seeds in a spiral pod, resulting in considerable variation in the form and size of individual seeds. (See figs. 6 and 26.) Seeds of the true clovers, alfalfa, trefoil, bur clovers, and sweet clover are more or less flattened and (excepting crimson clover) are notched in the edge. Within this notch the seed scar, or point of attachment to the plant, appears as a small but distinct ring. (See figs. 22 and 26.) In the more or less spherical seeds of the vetches the scar is an oval, wedge-shaped, or slender spot on the curved surface. (See fig. 32.) In this class of seeds the scar is an important mark of distinction. In several of the small-seeded kinds of leguminous plants occasional pods appear even in well-cleaned lots of seed. (See figs. 22, 23, and 27.)

Most of the grass seeds, also oats and barley, appear "in the chaff," that is, the grains or kernels of the seed, illustrated by the kernels of wheat and the hulled seeds of timothy, are usually covered by the dried chaffy flower scales. (See fig. 16.) The difference in size, form, and structure of this chaff marks the different kinds of grass seeds.

Seeds of the grasses.—Grass seeds are produced in clusters (spikelets). Some clusters contain several seeds arranged along a common axis (rachilla). At maturity the clusters break apart, each seed carrying a piece of the cluster axis (rachilla segment). Such seeds have two chaff scales, one (the lemma) larger than the other (the palet or palea). (See fig. 16.) Examples of this class of grass seeds are found in orchard grass, meadow fescue, rye-grass, brome-grass, and in the bluegrasses. (See figs. 10 and 9.) In another class of grasses each cluster contains but a single seed which, therefore, has no rachilla segment. The seeds of broom-corn (or grain) millet are a good example of this class, the seed scales, lemma, and palea being hard, smooth, and shining. (See fig. 31, **a**.) Part of the seed of foxtail millet, Japanese millet, and the foxtail weeds differs structurally from the last only in being covered by two or three additional chaffy scales, which constitute the "outer chaff." (See fig. 31, **b** and **c**.)

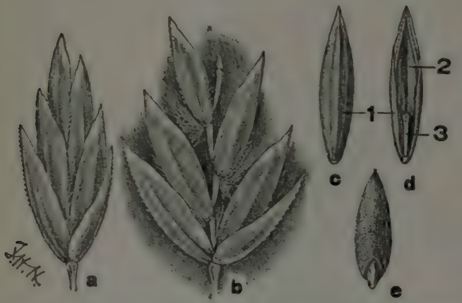

FIG. 16.—A spikelet and florets ("seeds") of Kentucky bluegrass: **a**, Spikelet as it appears at maturity; **b**, the same having the florets spread apart, showing the jointed rachilla; **c**, back view of a floret, showing the lemma (1); **d**, front view of the floret, showing the edges of the lemma (1), the palet (2), and the rachilla segment (3); **e**, the grain or kernel of the seed.

These features of form and structure are easily recognized when representative seeds come to be compared under a magnifier, and it is advisable to understand them in making tests of clover and grass seeds, because the element of certainty is essential to satisfactory results.

IMPURITIES OF FARM SEEDS.

CLASSIFICATION.

The impurities carried by farm seeds have an important bearing on the real quality of the seed. Their quantity may be sufficient to unduly increase the cost of the good seed and their character may be that of injurious weeds.

Seed impurities are classified (1) as inert material and (2) as foreign seed, including both other crop seed and weed seeds.

INERT MATERIAL.

The inert material constitutes essentially such impurities as will not grow (exclusive of dead seed), as chaff, empty seed hulls, broken seed, pieces of stems and leaves, sand, dust, etc. The chief objection to such material is that it replaces good seed, thus increasing the cost. In grass seed the inert chaff misleads by causing the seed to present a better appearance than its quality justifies, as in bluegrass seed and chaff redtop seed. As compared with weed seeds, inert material is of minor importance, a fact not to be overlooked in the purchase and use of seed. The practical seed test should point out clearly the relative importance of the inert matter and of the weed seeds found in the sample.

OTHER CROP SEEDS.

Seed of various farm crops sometimes constitutes a part of the foreign seed. Its proportion as compared with the weed seed should be noted in making the purity test. The importance to be attached to the occurrence of such crop seed depends on its nature; for illustration, the presence of timothy seed is detrimental to alsike clover seed used with a view to alsike seed production, while for hay production a mixture of timothy and alsike seed often is preferable.

WEED-SEED IMPURITIES.

Quantity and Kinds of Weed Seeds.

Very few samples of forage-crop seeds are found wholly free from weed seeds. The methods of culture and of harvesting in vogue operate against a pure seed crop. The proportion of the weed seeds appearing incidentally in the marketed seed is dependent on the number and character of the weeds in the seed-producing crop and the extent to which the seed has been cleaned before being marketed.

Weed seeds occurring in farm seed are of interest to the buyer of seed (1) in respect to their total quantity and (2) in respect to their kinds. In many instances low-grade seed contains so much weed seed that the quantity of the crop seed is thereby greatly reduced in a given weight of seed. Of the kinds of weed seeds 300 to 400 are known to occur in the various kinds of the common crop seeds. Occasionally from 75 to 100 kinds of weed seeds are to be found in a single sample of red clover or alfalfa seed not exceeding a few ounces in weight. In some instances one or more kinds of weed seed are very abundant in the sample. As a rule, however, most of the kinds are represented by only a few seeds.

The important question in regard to the kinds of weed seeds found in crop seed is whether the plants they produce are injurious or relatively unimportant. Some of the weed seeds commonly found in seed produce plants which are very detrimental to the crop or to the land. Everyone making tests of seed should become familiar with the seeds of injurious weeds. Most of the weed seeds found in making tests are seeds of comparatively harmless plants, and their recognition as to kind becomes more a matter of interest than one of practical importance.

Certain kinds of crop seeds, as clover, alfalfa, awnless brome-grass, etc., are supplied to the American market from both foreign and domestic sources. Since domestic seed is generally preferable to that which is imported, the source of the seed as indicated by the weed seeds it contains gives an added interest to some kinds of weed seeds. Thus the presence of seeds of perhaps several kinds of native weeds in a sample of clover seed or of alfalfa seed, together with the absence of seeds commonly found in imported seed, practically amounts to proof of its domestic production. Foreign production is strongly suggested by reverse conditions. Many kinds of weed seeds found in imported seed grow and produce plants in this country, it is true, but the growth or seed production of the plants is so meager or is so restricted to certain localities that their seeds rarely or never appear in the American-grown seed crop. When such seeds appear as several kinds together, or in abundance, they practically prove the foreign origin of the seed containing them.

The illustrations of weed seeds presented here show the seeds classified (1) as noxious weed seeds found in farm seeds (figs. 17 and 18) and (2) as other weed seeds commonly found in farm seeds (figs. 19, 20, and 21). The figures, together with the brief descriptions of distinguishing characters, should enable one readily to recognize these seeds when examined with a magnifier. Weed seeds that are found with the several kinds of clover, grass, and cereal seeds are mentioned under the subsequent discussion of the testing of these crop seeds.

Noxious Weed Seeds Found in Farm Seeds.

The following brief descriptions point out the most conspicuous distinctions between the seeds of various noxious weeds. They only supplement the illustrations to which they refer and which show the general form and structure and the natural size of the seeds. The serial order is employed for ready reference in the subsequent discussion of testing particular kinds of seeds.

The seeds of sand bur (fig. 17, **a**) have somewhat the appearance of small wheat kernels, usually light brown or straw colored; common in alfalfa seed from the Great Basin region. The spiny burs of this grass reduce the feeding quality of alfalfa hay.

The seeds of wild oats (fig. 17, **b**) are similar to seeds of cultivated oats, but always have a twisted and bent, brown or straw-colored awn (sometimes broken away) from near the middle, a tuft of light-brown hairs on the rachilla segment and about the characteristic, cup-shaped rim of the scar at the base of the seed; widely distributed and common in seeds of cereals (especially oats) and large-seeded grasses.

Chess (or cheat) seeds (fig. 17, **c**) are straw colored, sometimes greenish or brown when in the chaff (as figured), the awn at the apex often broken away, the club-shaped form of the rachilla segment distinguishing this from cultivated grass seeds; common in seeds of cereals and large-seeded grasses generally; the reddish-brown, trough-shaped free grains sometimes appear in clover seed.

Darnel seeds (fig. 17, **d**) are robust, straw colored, and in the absence of the slender awn somewhat resemble large seeds of meadow fescue and English rye-grass; common in seed of cereals, particularly wheat.

Quack (or couch) grass seeds (fig. 17, **e**) closely resembles fescue and rye-grass seeds, but they are usually slenderer, light (or yellowish), sometimes greenish colored; whole spikelets having the two empty scales noticeably joined at the same level at the base of the spikelet (thus differing from most grass spikelets) are invariably found with the individual seeds. Commonly found in seeds of cereals and the coarse grasses, especially in the seed of awnless brome-grass imported from Europe.

Dock seeds (fig. 17, **f**) are sharply 3-angled, reddish brown, smooth, and shining; one of the commonest of the weed seeds of farm seeds generally, the reddish-brown ripened flowers (shown at the right of the figure) commonly appearing in seeds of cereals and coarse grasses. Several kinds of dock seeds occur in farm seeds, the commonest being that of curled dock (figured). The similar seeds of broad-leaved (or bitter) dock are sometimes found. Another kind having smaller seeds which are rounded instead of pointed at the base occurs in Chilean red clover seed.

Black bindweed seeds (fig. 17, **g**) are coarse, 3-angled, black when the outer covering is removed; the outer straw-colored, greenish, or brown covering (flower scales) may be present or partly or wholly broken away; common in all kinds of coarse farm seeds from all sources, particularly in seed of cereals, millet, and flax.

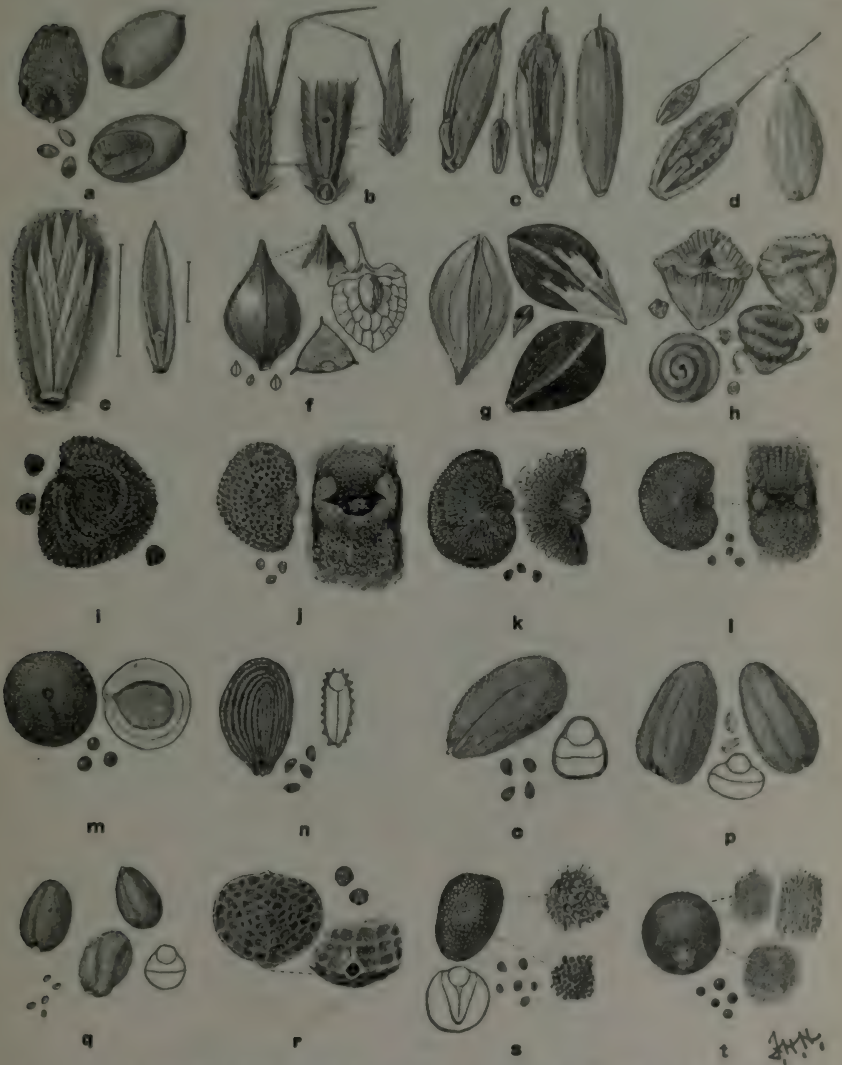

FIG. 17.—Noxious weed seeds found in farm seeds (No. 1): **a**, Sand bur; **b**, wild oat; **c**, chess; **d**, darnel; **e**, quack-grass; **f**, dock; **g**, black bindweed; **h**, Russian thistle; **i**, corn cockle; **j**, white campion; **k**, bladder campion; **l**, night-flowering catchfly; **m**, cow cockle; **n**, pennycress; **o**, field peppergrass; **p**, large-fruited false flax; **q**, small-fruited false flax; **r**, ball mustard; **s**, black mustard; **t**, English charlock. (Enlarged and natural size.)

Russian thistle seeds (fig. 17, **h**) occur both with and without the gray or light-brown hull (flower scales); the seeds proper have a thin coat covering the slender spirally coiled, greenish embryo; common in alfalfa seed from the Western States and in flaxseed; doubtless occasionally introduced in seed from Russia. As an impurity of alfalfa seed it strongly suggests Western States production.

The seeds of corn cockle (fig. 17, **i**) are black or brown, angular, and covered with fine spiny tubercles; common in seed of cereals, millets, vetches, and flax from all sources.

White campion seeds (fig. 17, **j**) are mostly light gray, the surface finely tubercled, the light color distinguishing this kind from the next two; common in imported crimson clover and grass seeds; sometimes found in red clover seed.

Bladder campion seeds (fig. 17, **k**) are brown or nearly black, flattened, finely tubercled, the tubercles arranged in more or less distinct rows on the sides and in more distinct rows on the edges; occurs frequently in imported grass seed and is sometimes abundant in seed of red and alsike clovers grown in the Northern States and in Canada.

Night-flowering catchfly seeds (fig. 17, **l**) are similar to the preceding, dark gray or brown, finely tubercled, the tubercles not in distinct rows on the sides; very common and often abundant in seed of red and alsike clovers grown in the Northern States and in Canada. Careful comparison of seeds with the illustrations (fig. 17, **j**, **k**, and **l**; fig. 19, **t**) will enable one to distinguish the similar seeds of this group of weeds. Figure 19, **t**, shows the seed of the forked catchfly, which is common in low-grade European red clover and alfalfa seed.

The seeds of cow cockle (fig. 17, **m**) are almost perfectly spherical, black, the surface covered with fine tubercular points; very common in seeds of cereals from the West and Northwest; also in millet and flax seeds, sometimes in imported coarse seeds; broken seeds often occur in alfalfa seed from the Western States, thus indicating its source.

Pennycress (or Frenchweed) seeds (fig. 17, **n**) are oval, flattened, brown, and have concentric ridges on the sides; often found in both domestic and imported seed of cereals, clovers, millets, and flax. This is a dreaded weed in the Northwestern States.

Field peppergrass seeds (fig. 17, **o**) are reddish brown, oval, smooth, and show a curved line on each side; common in domestic and imported seed of various clovers, grasses, and cereals.

False flax seeds (fig. 17, **p** and **q**) as found in farm seeds represent two kinds of false flax (plants in no way related to the true flax). Seeds of the large-fruited false flax (fig. 17, **p**) are light yellow and much larger than those of the other kind; very common in flax seed (hence the common name); also, in millet and sometimes in alfalfa seed; common in coarse farm seeds from Russia. Seeds of small-fruited false flax (fig. 17, **q**) are much smaller than the others, and darker, being reddish yellow; common in Canadian red and alsike clovers and timothy seed.

Ball mustard seeds (fig. 17, **r**) are unopened, straw-colored, brown or purplish pods, having a network of ridges over the surface and containing a single yellowish seed within; found in seed of cereals, millets, and flax; sometimes in imported seed. This is a troublesome weed in certain sections of the Northern States.

Black mustard seeds (fig. 17, **s**) are small, commonly somewhat oblong, and reddish brown or dark brown, sometimes gray, surface pitted, due to a network of ridges; taste distinctly pungent; sometimes found in clover and grass seeds.

English charlock, or wild mustard, seeds (fig. 17, **t**) are almost spherical, slightly variable in size, black, reddish brown, or sometimes light brown, the surface comparatively smooth, which distinguishes this seed from seed of other mustards and rape; taste somewhat pungent; a frequent impurity of nearly all the common clover, grass, and cereal seeds; sometimes an adulterant of rape seed.

Indian (or brown) mustard seeds (fig. 18, **a**) are oblong-spherical, averaging larger than those of charlock, light-reddish brown, the surface having a distinct network of fine ridges; taste not pungent; occurring chiefly in seeds of cereals, millets, and flax; common in imported flax seed; sometimes mixed with rape seed.

Hare's-ear mustard seeds (fig. 18, **b**) are oblong, surface granular, dark brown, and if placed in water develop mucilage which forms whitish projecting points over the surface on drying; common in seed of cereals, millets, and flax; often in imported seed. This is an objectionable weed of the Northern States.

Tumbling mustard seeds (fig. 18, **c**) are very small, flattened, oblong, and yellowish, often with a greenish line along the side; found in clover and flax seed from the Northwest.

Wild carrot seeds (fig. 18, **d**) are light brown, oval, flattened, nearly plane on one side and ridged lengthwise on the other, the ridges often bearing the remnants of whitish spines; common in red clover and in imported alfalfa seeds, sometimes found in grass seed.

Field bindweed seeds (fig. 18, **e**) are coarse, oval, rounded on one side and angular on the other, gray, owing to numerous light-colored raised spots on the surface; common in seeds of cereals, in flax, and in other coarse seeds.

Seeds of the dodders (fig. 18, **f-j**) as a group are recognized by their dull, finely roughened surface, together with their rounded or angular form and their small size.

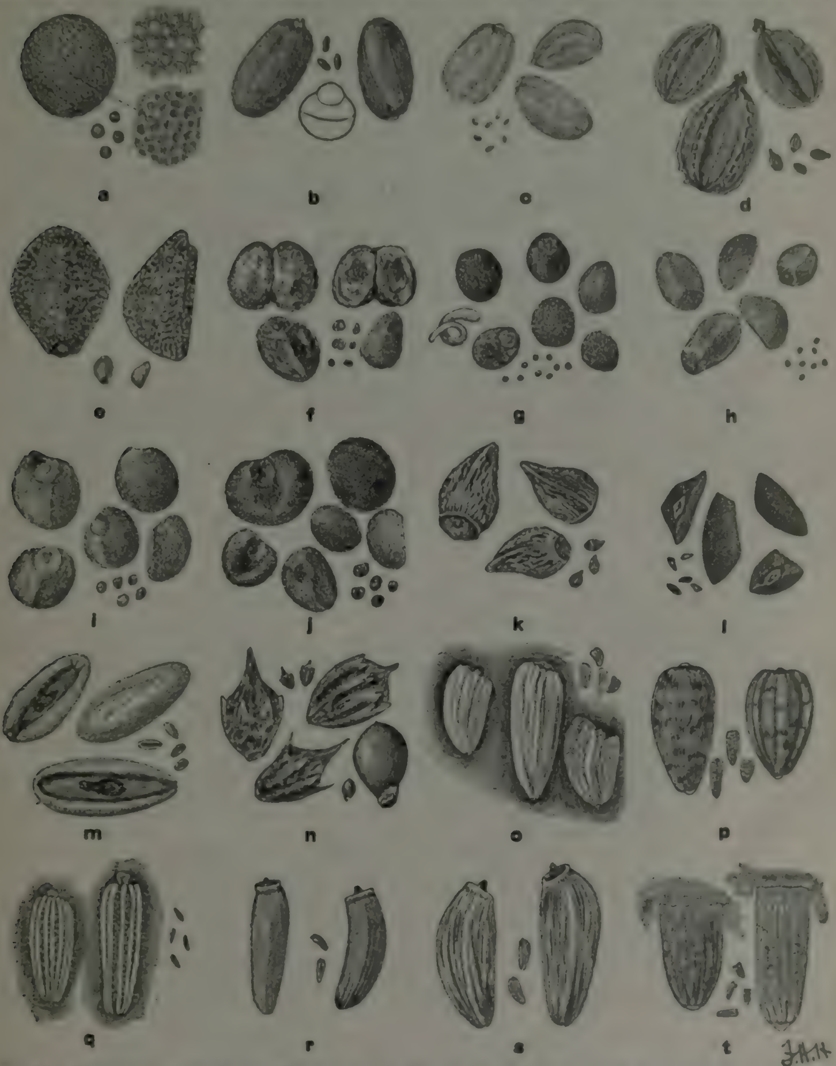

FIG. 18.—Noxious weed seeds found in farm seeds (No. 2): **a**, Indian mustard; **b**, hare's-ear mustard; **c**, tumbling mustard; **d**, wild carrot; **e**, field bindweed; **f**, flax dodder; **g**, clover dodder; **h**, small-seeded alfalfa dodder; **i**, field dodder; **j**, large-seeded alfalfa dodder; **k**, corn gromwell; **l**, rat-tail plantain; **m**, buckhorn; **n**, ragweed; **o**, gumweed; **p**, wild sunflower; **q**, oxeye daisy; **r**, Canada thistle; **s**, bull thistle; **t**, wild chicory. (Enlarged and natural size.)

The slender spirally coiled embryo of the seed, devoid of two cotyledons, is characteristic of dodder seed.[a]

Flax dodder seeds (fig. 18, **f**) are rounded on one side and angular on the other, many of the seeds united together in pairs; soiled gray in color; found only in flax seed; common in imported seed and in some domestic seed. (See fig. 12.)

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[a] See Farmers' Bulletin 306, "Dodder in Relation to Farm Seeds."

Clover dodder seeds (fig. 18, **g**) are very small, nearly spherical as a rule, gray or brown; often distinctly pitted; common in imported clover and alfalfa seeds; not found in grass seed. (See figs. 1 and 2.)

Small-seeded alfalfa dodder seeds (fig. 18, **h**) are similar in size to seeds of clover dodder, but are more oval and angular in form; colors yellowish, greenish, or purplish; common in alfalfa seeds from the Western States. Of the dodders infesting alfalfa this is the most widely distributed within the United States. Its seed is not found in red clover or grass seeds.

The seed of clover dodder and small-seeded alfalfa dodder are sufficiently small to admit of being wholly removed from clover or alfalfa seed of good grade by the use of a sieve of proper mesh (about 20 to the inch). Clover dodder is a menace in any part of the country. Small-seeded alfalfa dodder appears to be naturally confined to the dry regions of the West.

Field dodder seeds (fig. 18, **i**) are larger than those of clover or small-seeded alfalfa dodder, rounded on one face and flattened and angular on the other; the characteristic seed scar is a more or less distinct, circular area having a short, raised whitish line in its center; seeds from the Great Basin region gray or pinkish, those from Chile (evident in Chilean red clover and alfalfa seed) reddish brown; found in both red clover and alfalfa seed, commonest in western-grown alfalfa seed and in Chilean red clover and alfalfa. The plants are very destructive to clover and alfalfa.

Large-seeded alfalfa dodder seeds (fig. 18, **j**), the largest of the dodders found in alfalfa, are variable in size; some are not larger than and are similar to the seeds of field dodder; the largest are nearly circular, rounded, and flattened; color gray, greenish, or more commonly brown; scar devoid of the raised whitish line to be seen in field dodder and often indistinct; found only in alfalfa seed produced in the Western States. This dodder does not appear to thrive in the Eastern States. Field dodder and large-seeded alfalfa dodder are termed large seeded because their seeds can not be wholly removed from clover and alfalfa seed. The greater part of the field dodder can be removed by the use of a sieve of 20 meshes to the inch.

Corn gromwell seeds (fig. 18, **k**) are oval, gray, or brown, and being very hard the name "stoneseed" is often applied to them; found in seed of red and crimson clovers, alfalfa, cereals, grasses, etc.

Rat-tail plantain seeds (fig. 18, **l**) are small, flat, angular, and black; the scar in the center of one side; common in seed of clovers and some grasses. Known also as broad-leaved plantain and as Rugel's plantain; a persistent weed.

Buckhorn seeds (fig. 18, **m**) are smooth, shining, rounded on one side with a deep groove on the other, brown or amber colored, becoming coated with mucilage when placed in water;[a] one of the commonest impurities of farm seeds, often very abundant in seed imported from Europe. Not abundant in alfalfa seed produced in the Western States. Known also as plantain, English or narrow-leaved plantain, and rib-grass.

Ragweed seeds (fig. 18, **n**) as they commonly occur are somewhat top shaped, usually with a crown of several teeth or spines; the outer covering is often broken away, the seed then appearing pear shaped, smooth, and brown; common in American red clover and in cereal grain.

Gumweed seeds (fig. 18, **o**) are whitish or straw colored, variable in form, sometimes wrinkled; found chiefly in alfalfa seed from the Western States.

Wild sunflower seeds (fig. 18, **p**) have the form and the striped, mottled appearance familiar in the cultivated sunflower seeds, but are much smaller; common in alfalfa seed and other seeds from the Western States.

Oxeye daisy seeds (fig. 18, **q**) are very small, but are readily distinguished by the 10 slender, white ridges which extend from end to end, one end usually bearing a knob-like projection; found frequently, but usually not abundant, in clover seed and small grass seed.

Canada thistle seeds (fig. 18, **r**) are smooth, light brown, straight or curved, having a cuplike rim at one end, a projecting point often within the rim; found in clover seed, particularly alsike from Canada; sometimes in seed of clover and grasses from Europe.

Bull thistle seeds (fig. 18, **s**) are larger than those of the Canada thistle, light colored, striped lengthwise with brown, the rim at one end often yellowish; common in red clover, alfalfa, and grass seeds.

Wild chicory seeds (fig. 18, **t**) are brown or straw colored, usually mottled, the crown scales at the broader end sometimes rubbed away; common in imported clover, alfalfa, and certain kinds of grass seeds, occurring in lesser degree in American-grown seed.

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[a] See "An Improved Method of Separating Buckhorn from Red Clover and Alfalfa Seeds," Circular 2, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1908.

Other Weed Seeds Commonly Found in Farm Seeds.

Certain kinds of weed seeds other than those termed noxious under the preceding heading are found frequently, sometimes abundant, in various kinds of farm seeds, and thus cause inquiry from one examining seeds. The degree of noxiousness of this class of weed seeds differs with the kinds and with the conditions of locality, climate, etc., under which they are sown. While some of the kinds included in the present list are looked upon, at least locally, as pests, many of the kinds mentioned are of little importance as field weeds. Since it is essential to distinguish the relatively unimportant from the important seeds, a fairly accurate classification of the weed seeds found in farm seeds with respect to their relative importance is a desirable feature of popular seed testing.

The following brief descriptions refer serially to illustrations of 60 kinds of weed seeds shown in figures 19, 20, and 21.

Crab-grass seeds (fig. 19, **a**) usually bear the outer chaff, which is often soft-hairy, one scale as long as the seed and distinctly 3-ridged, the other half the length of the seed; straw colored, brown, or purplish; common in seeds of clovers, alfalfa, and grasses; plants sometimes very troublesome.

Witch-grass seeds (fig. 19, **b**) occur both with and without the outer chaff, which is lance shaped, smooth, and brown; seeds freed from the chaff are oval, light gray or dark gray, smooth, and polished; common in seeds of clovers, alfalfa, and grasses; plants widely distributed; comparatively unimportant.

Yellow foxtail seeds (fig. 19, **c**) are oval, flat on one side and arched on the other, chaff straw colored, light brown, or greenish, as long as the seed on the flat face, a half-length scale on the arched face; the light-colored or dark-colored seed within the chaff distinctly ridged crosswise on the arched face, often free from the outer chaff; common in many kinds of farm seeds.

Green foxtail seeds (fig. 19, **d**) are oval, convex on both faces, the whitish or straw-colored outer chaff as long as the seed on both faces; seed within the chaff straw colored, gray, or brown, the darker seeds often mottled, the surface finely roughened and dull; common in many kinds of farm seeds. Both yellow and green foxtail grasses are widely distributed summer weeds occupying valuable space in crops. Green foxtail seeds are distinguished from seeds of foxtail millet by their smaller size and rough, dull surface.

Velvet grass seeds (fig. 19, **e**) usually appear in the chaff, which is thin, oval, and straw colored, the surface covered with fine, stiffish hairs; a single oval, shining seed usually found within the chaff; a common impurity of coarse grass seeds.

Soft chess seeds (fig. 19, **f**) are lance shaped, usually much flattened, straw colored, the lemma awned at its apex, its back usually wrinkled, the palea and grain shorter than the lemma; common in imported coarse grass seeds; widely distributed in the United States, but not an important weed except on the Pacific coast.

Sedge seeds (fig. 19, **g**) when covered by the chaffy hull are flask shaped, straw colored, brown, or greenish, flattened and thin with respect to the several kinds found in farm seeds; seeds freed from the outer chaff are oval, lens shaped, and light brown; common in grass seeds, particularly bluegrass seed; plants comparatively unimportant.

Sorrel (or sheep's sorrel) seeds (fig. 19, **h**) are small, oval, 3-angled, the outer chaffy hull dull reddish brown; seeds freed from the hull are reddish brown, smooth, and polished; found in farm seed both with and without the hull; a common impurity, appearing in seeds of clovers, grasses, poorly cleaned cereals, millets, etc.; a cosmopolitan weed often troublesome until subdued.

Knotweed seeds (fig. 19, **i**) are sharply oval, 3-angled, dull reddish-brown in the absence of the brown chaffy covering, a part of which is usually borne at the broader end; common in clover seed and grass seed; plants usually of minor importance as field weeds.

Pale knotweed seeds (fig. 19, **j**) are nearly circular, flattened, and chestnut brown when freed from the reddish-brown, sometimes adherent, chaffy covering; common in seed of coarse grasses, cereals, and flax, often abundant in imported seed. The plants grow chiefly in moist places and are not troublesome on uplands.

Lady's-thumb seeds (fig. 19, **k**) are usually free from the chaffy covering and are then black, shining, broadly oval, and flattened, or sometimes 3-angled; common in various kinds of farm seeds, particularly American-grown red clover seed. The habit of the plant is similar to that of the preceding knotweeds, to which it is closely related. This plant is common on dry uplands.

Lamb's-quarters (goosefoot) seeds (fig. 19, l) are small, lens shaped, dark brown, or black and shining, sometimes found within a chaffy covering of five scales; common in all kinds of farm seeds, particularly clover and grass seeds; a well-known weed of gardens, cultivated fields, and meadows.

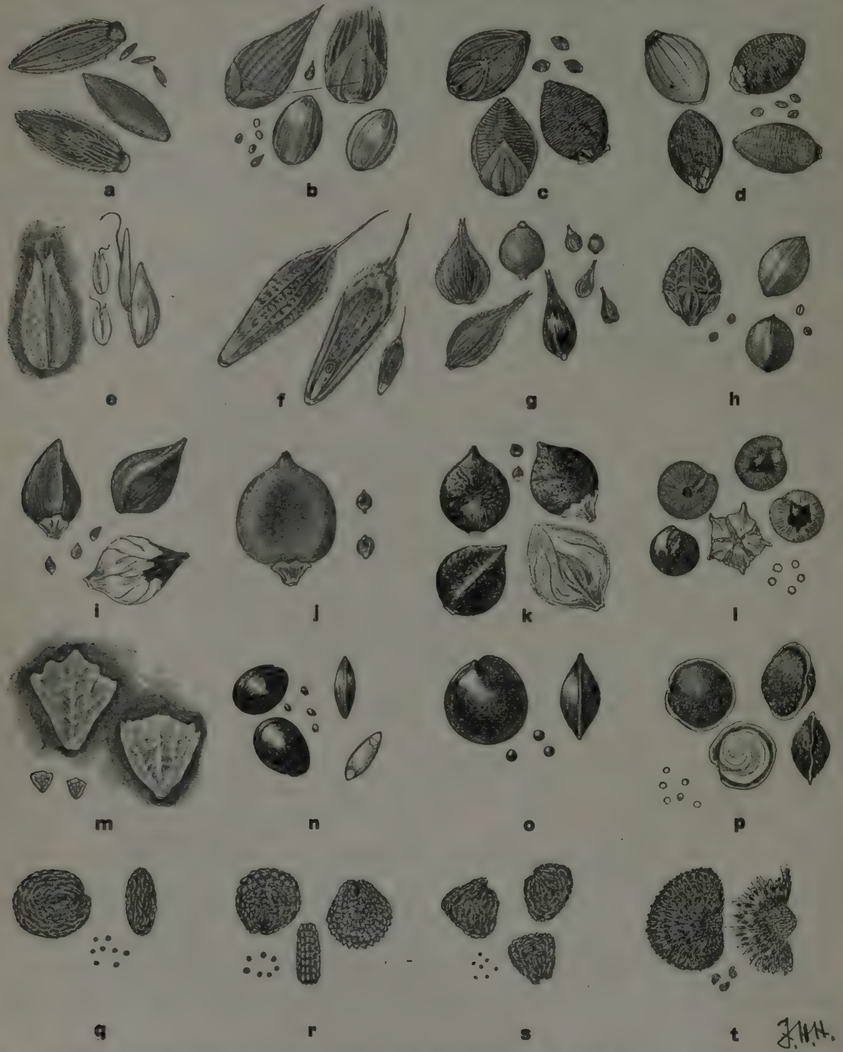

FIG. 19.—Other weed seeds commonly found in farm seeds (No. 1): **a**, Crab-grass; **b**, witch-grass; **c**, yellow foxtail; **d**, green foxtail; **e**, velvet grass; **f**, soft chess; **g**, sedge; **h**, sorrel; **i**, knotweed; **j**, pale knotweed; **k**, lady's-thumb; **l**, lamb's-quarters; **m**, wild saltbush; **n**, rough amaranth; **o**, spreading amaranth; ; **p**, wild spurry; **q** and **r**, chickweed; **s**, mouse-ear chickweed; **t**, forked catchfly. (Enlarged and natural size.)

Wild saltbush seeds (fig. 19, **m**) are thin, triangular or wedge shaped, veined, straw colored, or purplish, their two scales inclosing a single small seed; found in American-grown alfalfa, not appearing in imported seed.

Amaranth (pigweed) seeds (fig. 19, **n** and **o**) are lens shaped, black, and highly polished. Seeds of rough amaranth (fig. 19, **n**) are oval in outline; those of tumbling amaranth are somewhat smaller and nearly circular in outline, while seeds of spreading amaranth (fig. 19, **o**) are much larger and nearly circular in outline, the sides being strongly convex. Seeds of rough amaranth and of tumbling amaranth are common in various kinds of farm seeds, particularly clover. Spreading amaranth is native in the Western States and its seeds often appear in alfalfa from that region.

Wild spurry seeds (fig. 19, **p**) are very small, black, and nearly spherical. A narrow light-colored rim encircles the seed and serves to distinguish it from other weed seeds. Some seeds are flecked with whitish particles; common in imported clover seed.

Chickweed seeds (fig. 19, **q** and **r**) are small, mostly brown, nearly circular, and flattened; one kind (fig. 19, **q**), common in clover seed imported from Europe, has numerous interlacing wrinkles covering the surface, the other kind (fig. 19, **r**) is borne by a common weed in lawns, gardens, and thin meadows, has the surface covered with individual tubercles arranged in more or less distinct rows, and is found in both imported and domestic clover seed.

Mouse-ear chickweed seeds (fig. 19, **s**) are minute, flattened, wedge shaped, tubercled, and distinctly reddish brown; common in small clover and grass seeds, particularly in alsike and timothy produced in Canada. This is a somewhat insignificant weed of lawns and thin meadows.

Forked catchfly seeds (fig. 19, **t**) are very similar to those of white campion (fig. 17, **j**), bladder campion (fig. 17, **k**), and night-flowering catchfly (fig. 17, **l**), but differ in having the tubercles on each face of the seed arranged in a few distinct rows. These kidney-shaped brown seeds often appear in European-grown red clover and alfalfa seed.

Creeping buttercup seeds (fig. 20, **a**) are oval, flattened, brown or reddish brown, with a lighter rim, and have a prominent, straight, or slightly curved beak; common in imported crimson clover, meadow fescue, and rye-grass seeds.

Peppergrass seeds (fig. 20, **b**) are oval, flattened, thin, reddish yellow, and have a curved groove on each face; common, and sometimes abundant, in clover and grass seeds, particularly in timothy; a widely distributed annual weed of waysides, gardens, and meadows.

Shepherd's-purse seeds (fig. 20, **c**) are minute, reddish yellow, oblong, and flattened, with two more or less distinct grooves on each face; common in seeds of white, alsike, and poorly cleaned red clovers; a cosmopolitan, annual weed.

Cinquefoil seeds (fig. 20, **d**) are minute, straw colored, oval, and lens shaped, the faces bearing curved and forked ridges; common in alsike clover and timothy.

Hop clover seeds (fig. 20, **e**) are minute, elliptical, yellowish, the surface smooth and shining; common in poorly cleaned clover seed. The reddish flowers (shown at the right of the figure) are common in imported orchard grass, meadow fescue, and rye-grass seeds.

Yellow trefoil seeds (fig. 20, **f**) are oval with a projecting point on the edge, yellowish brown, or tinged with green. Besides being used as an adulterant of clover and alfalfa seed, some seeds occur incidentally in clover and grass seeds. Mature, black, oval pods or immature green pods are common in coarse grass seeds. The plants are widely distributed here and in foreign countries.

Bird's-foot trefoil seeds (fig. 20, **g**) are small, nearly spherical, brown, and often mottled; frequently found in imported clover and alfalfa seeds; a cultivated plant in Europe.

Wild geranium seeds (fig. 20, **h**, **i**, and **j**) as commonly found in farm seeds represent three kinds of plants. Seeds of one kind (fig. 20, **h**) are oblong and pitted, having a whitish or light-brown network over a darker brown background (thus readily distinguished from other seeds); common in imported crimson clover and coarse grass seeds. Another kind (fig. 20, **i**) has smaller, smooth, rounded seeds which are often covered by a brown hull bearing several diagonal ridges on each side; often found in imported clover and grass seeds. A third kind (fig. 20, **j**) has more oval, smooth seeds, some of which are covered by a somewhat flattened, finely hairy hull; found in imported clover and grass seeds.

Stork's-bill seeds (fig. 20, **k**) are somewhat club shaped, smooth, brown, and often covered by a sharp-pointed, brown, hairy hull; found in clover, alfalfa, and grass seeds; commonest in imported seed.

Spurge seeds (fig. 20, **l**) are steel gray or dark brown, oval, and somewhat 4-angled, the angles lightest colored, a few cross-ridges between the angles, one of the angles bearing a slender, black line; common in American red clover seed.

Spiny sida seeds (fig. 20, **m**) are brown, rounded on one side, angular on the other, and notched at the broader end; common in American-grown red clover seed; the forked, often netted-veined seed vessels (shown at right-hand side of figure) sometimes appear in poorly cleaned clover, but are more common in grass seeds.

Evening primrose seeds (fig. 20, **n**) are small, reddish brown, and angular, prismatic, or curved; the corners are thin-edged, the faces finely grooved; common in timothy and sometimes found in clover seed.

Red pimpernel seeds (fig. 20, **o**) are small, 3-angled, and reddish brown; surface finely roughened or sometimes partly smooth and black; somewhat resemble seeds of sorrel (fig. 19, **h**) having the chaffy covering; very common in imported clover and alfalfa seeds, often in grass seed.

Sticktight seeds (fig. 20, **p**) are small, oval, brown burs having many barbed prickles; when in clover, most of the prickles are usually broken away; when in grass seeds, some or all of the prickles are usually uninjured; found in red clover, particularly that from Canada, in seed of coarse grasses, millets, cereals, and flax; often in seed imported from Europe.

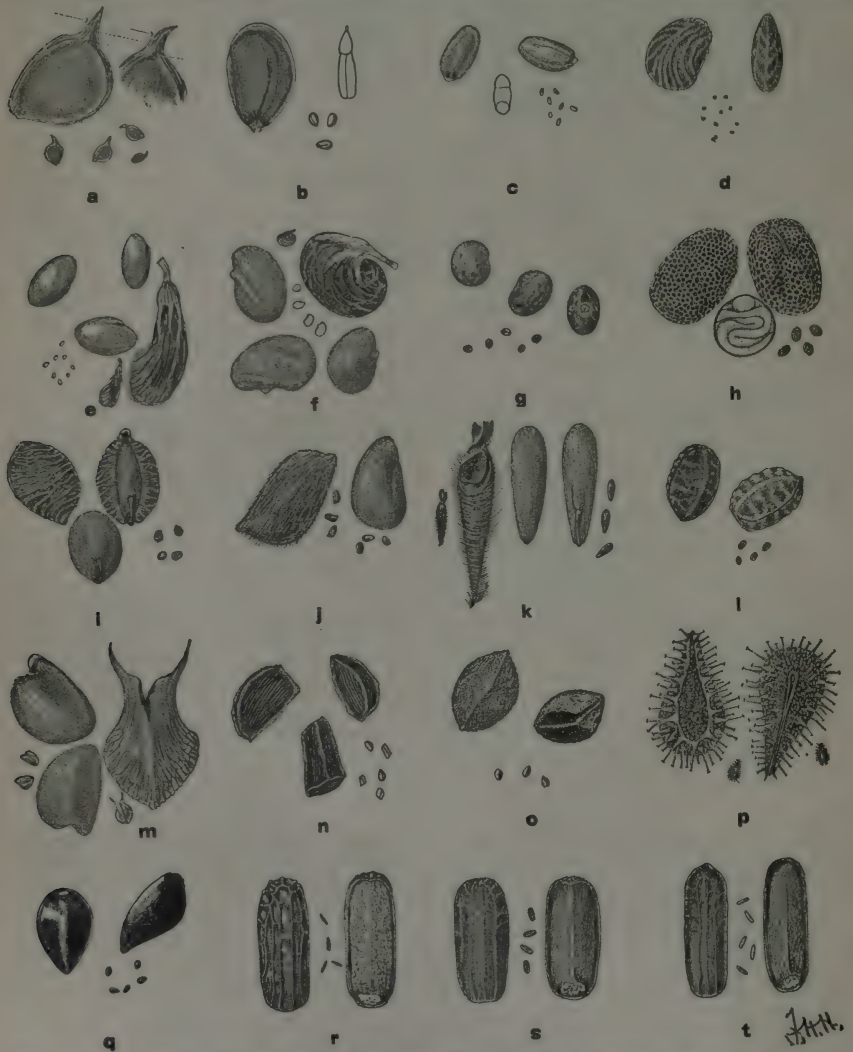

FIG. 20.—Other weed seeds commonly found in farm seeds (No. 2): **a**, Creeping buttercup; **b**, peppergrass; **c**, shepherd's-purse; **d**, cinquefoil; **e**, hop clover; **f**, yellow trefoil; **g**, bird's-foot trefoil; **h**, **i**, and **j**, wild geraniums; **k**, stork's-bill; **l**, spurge; **m**, spiny sida; **n**, evening primrose; **o**, red pimpernel; **p**, sticktight; **q**, forget-me-not; **r**, **s**, and **t**, vervain. (Enlarged and natural size.)

Forget-me-not seeds (fig. 20, **q**) are small, black, shining, oval, rounded on one face, and angled on the other; common in imported clover and grass seeds.

Vervain seeds (fig. 20, **r**, **s**, and **t**) are oblong, reddish or dark brown, veined on one side, angled and often gray on the other. One kind (fig. 20, **r**) has a distinct network of ridged veins on the back, the surface between the veins shining; common in European clover and alfalfa seeds. The other two kinds of vervain commonly found in farm seeds have indistinct veins on the back which is dull, one of them (fig. 20, **s**) being comparatively broad and brown; the other (fig. 20, **t**) being slender and lighter, reddish colored; seeds common in American-grown clover seed.

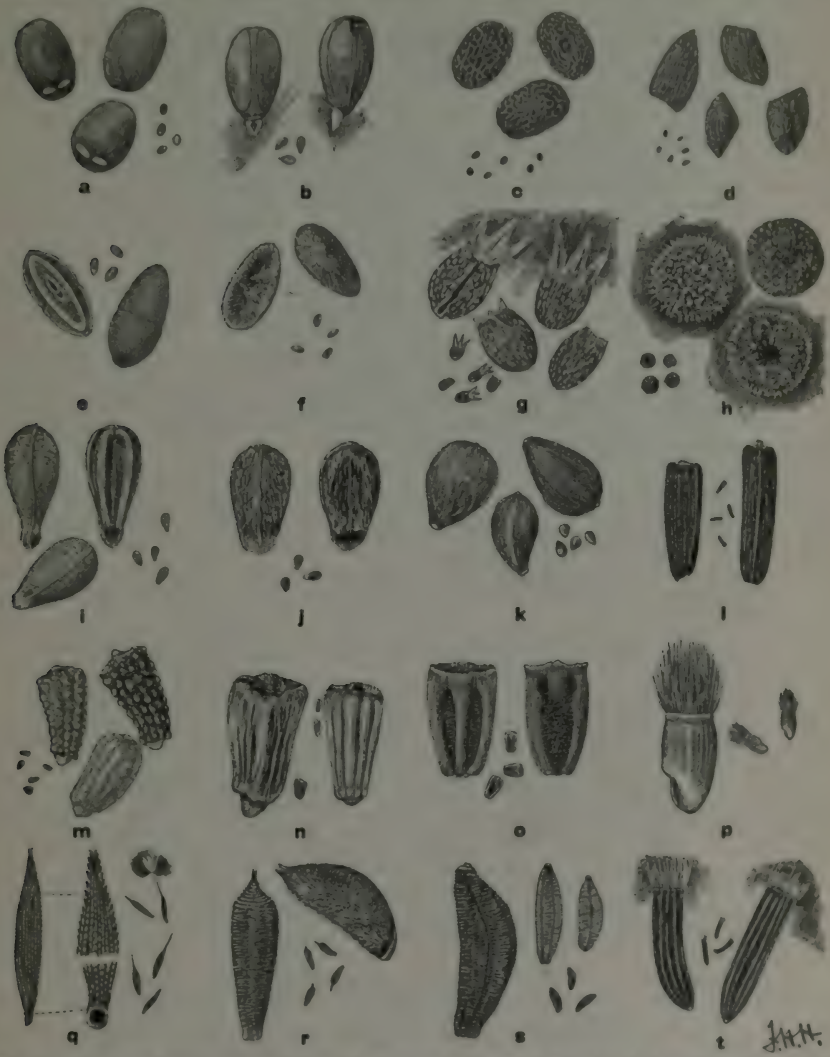

FIG. 21.—Other weed seeds commonly found in farm seeds (No. 3): **a**, Catmint; **b**, healall; **c**, rough-leaved toadflax; **d**, smaller broad-leaved plantain; **e**, bracted plantain; **f**, dwarf plantain; **g**, field madder; **h**, cleavers; **i** and **j**, wild corn salad; **k**, poverty weed; **l**, black-eyed Susan; **m**, dog fennel; **n**, field camomile; **o**, scentless camomile; **p**, corn flower; **q**, cat's-ear; **r**, oxtongue; **s**, hawkweed picris; **t**, hawkweed. (Enlarged and natural size.)

Catmint seeds (fig. 21, **a**) are oval, dark reddish brown or darker, smooth and dull, readily distinguished by the two white scar spots, side by side at one end of the seed; common in clover seed, particularly Canadian-grown alsike.

Healall seeds (fig. 21, **b**) are light brown, oval, with a characteristic whitish appendage at the pointed end, faint dark lines traversing the faces and edges; one of the commonest impurities of both domestic and imported clover and grass seeds.

Rough-leaved toadflax seeds (fig. 21, **c**) are very small, oblong, having a light-brown, wrinkled surface; plants not evidently important, but the seeds, as common impurities of imported clover seed, indicate the foreign origin of the lots containing them.

The smaller broad-leaved plantain seeds (fig. 21, **d**) are similar to those of rat-tail plantain (fig. 18, **l**), but are smaller, greenish or brown, the surface having slender, wavy dark lines; common in poorly cleaned clover and grass seed.

Bracted plantain seeds (fig. 21, **e**) are similar to those of buckhorn (fig. 18, **m**), but they are broader, dull reddish brown, and the broad groove on one face is bordered by a white stripe; the rounded face is crossed near its center by a shallow groove; common in American-grown red clover seed; sometimes found in alfalfa and grass seeds and occasionally in imported seed; a common annual plant of light lands.

Dwarf plantain seeds (fig. 21, **f**) are light brown, oval, rounded on one face, and broadly grooved on the other; found in crimson clover seed produced in Atlantic Coast States.

Field madder seeds (fig. 21, **g**) are oval, gray in having numerous white surface spots, some of the seeds having three frail, whitish teeth, others devoid of the teeth; common in seed of clover, alfalfa, and grasses; confined chiefly to imported seed.

Cleavers seeds (fig. 21, **h**) are coarse, circular, one face rounded, the other depressed in the center; the surface is covered with hair-bearing tubercles from which the hairs may be more or less rubbed away; the entire outer surface is sometimes rubbed away, leaving the seed smooth and brown; common in seed of coarse grasses, millets, cereals, and flax; a common impurity of imported seed.

Seeds of wild corn salad representing two kinds, commonly appear in clover imported from Europe. They are brown, one kind (fig. 21, **i**) being slenderly oval and nearly smooth, the other (fig. 21, **j**) being broader and usually more or less covered with white hairs. The presence of these seeds in clover indicates its foreign production.

Poverty weed seeds (fig. 21, **k**) are oval and dull brown, straight, or somewhat curved. They occur in alfalfa seed from the Western States; not found in foreign-grown seed.

Black-eyed Susan, or yellow daisy, seeds (fig. 21, **l**) are minute, black, prismatic, finely ridged lengthwise, and 4-angled; found chiefly in timothy seed.

Mayweed (dog fennel) seeds (fig. 21, **m**) are oval or club shaped, straw colored or brown, ridged lengthwise, the ridges more or less distinctly tubercled; very common in both domestic and imported seed of clover and grasses.

Field camomile seeds (fig. 21, **n**) are prismatic, some broad and deeply grooved lengthwise, others slender and lightly grooved or smooth; color whitish, light brown, or dark brown; common in domestic and imported clover and grass seeds.

Scentless camomile seeds (fig. 21, **o**) are prismatic, the surface rough and black, one face having three prominent brown ribs, the other showing two of these ribs and a partial third rib; common in poorly-cleaned clover seed and grass seed, particularly the seed of sweet vernal grass imported from Europe.

Corn flower (blue bottle) seeds (fig. 21, **p**) are easily recognized by the bluish color of the body of the seed and the tawny color of the brush of bristles each bears; common in both domestic and imported coarse seeds, including crimson clover, grasses, cereals, millets, and flax.

Cat's-ear seeds (fig. 21, **q**) are slender, reddish brown, rough, and sometimes bear a slender beak tipped by a brush of whitish bristles; found in clover seed and grass seed, a common impurity of imported seed.

Oxtongue seeds (fig. 21, **r**) are mostly lance shaped, reddish yellow, the surface having dark transverse lines, the margin at the broader end of the seed roughened (as shown at the left of the figure); a part of the seeds whitish, curved, the inner curved edge white-hairy (shown at the upper right-hand of the figure); common in poorly cleaned red clover and alfalfa seed imported from Europe; not found in domestic-grown seed.

Hawkweed picris seeds (fig. 21, **s**) are reddish brown, straight or curved, bearing fine transverse, dark-edged ridges, the faces of the seed having one or two slender grooves lengthwise; frequently found in imported red clover and alfalfa seed.

Hawkweed seeds (fig. 21, **t**) are small, black, cylindrical, ridged lengthwise, pointed at one end, the opposite end bearing a short brush of fine, white bristles; common in grass seed. The seeds of several kinds of hawkweed are similar. One kind is the orange hawkweed, which has proved troublesome in the Northeastern States.

DETAILS OF MAKING SEED TESTS.

Procedure.—Certain details of procedure in making seed tests should be followed if tests of seeds of different kinds are to be fairly comparable. The natural course to be followed in testing forage-crop seeds involves, in general, the preparation of the small sample for actual test, its examination, the separation of the crop seed and its impurities, a test of the germinating power of the crop seed, and the determination of the actual value of the seed as compared with pure seed.

Careful work in making a test is comparatively useless if the sample does not fairly represent the bulk of the seed from which it is taken.

The responsibility for selecting the small trade sample rests entirely with the dealer who submits it. When seed in bulk, as in a sack, is to be sampled, small amounts of seed should be taken from the top, bottom, sides, and center of the sack. If the sack be emptied and the seed thoroughly mixed, it is probable that a fairer sample can be taken.

The test sample.—Since the small sample thus taken or the trade sample will be too large to be tested in its entirety, it must be again subdivided to obtain the test sample. In official tests this all-important subdivision is effected by the use of a mechanical mixer, which takes a little from all parts of the larger quantity. In home testing perhaps there is no better plan than to pour the seed in a symmetrical pile on a flat surface and carefully subdivide it by means of a table knife. A subdivision amounting to a teaspoonful for the clovers and small-seeded grasses, a tablespoonful for the coarse grass seeds, and a considerably larger amount for cereal grains may be accepted for the test.

The balance previously described (p. 11) having been put in proper condition for use, the total weight of the selected sample is to be taken and recorded in terms of whole and fractional shots. This permits the computation of percentages by ordinary division according to the methods used in percentage. If, however, quantities of seed balancing 6¼ or 12½ shots are used, the one-sixteenth shot weight represents 1 per cent or one-half of 1 per cent, as heretofore explained.

The pure seed.—After the sample is weighed it is spread on a sheet of white paper folded in the form of a tray (p. 14) and should first be examined with reference to whether it is true to name. Attention should then be directed to the possible presence of some particular adulterant liable to be present. All the foreign seeds (except certain adulterants), including other crop seeds and weed seeds, also inert matter, as pieces of stems, chaff, sand, and badly broken seeds, are to be separated from the kind under test. Both plump and shriveled crop seed should be classed as "pure seed." While the shriveled seed very evidently may be worthless, it nevertheless is a part of the crop seed, and its worthlessness will appear in the subsequent germination test.

If certain specific adulterants, as trefoil, sweet clover, bur clover, Canada bluegrass, and rye-grass, are found, the adulterant seeds are left mixed with the crop seed when the other foreign seeds are separated. The proportion of the adulterant is then determined by count from a part of the mixture.

If certain kinds of foreign crop seeds or of weed seeds are especially abundant it may be desirable to keep them separate from the rest in order to determine their quantity, but if not the foreign matter for convenience may be mixed together irrespective of its character. In official tests the foreign seed and the inert matter are separated, their quantities being determined individually. After the pure seed and the foreign materials of the sample have been separated the proportion of pure seed is determined by comparing its weight with that of the entire sample, expressing the result in per cent. If quantities of seed weighing 6¼ shots or 12½ shots have been taken for the original test sample, each $\frac{1}{16}$-shot weight of pure seed represents 1 per cent or one-half of 1 per cent, respectively.

Determination of adulterants.[a]—When an adulterant is found and its kind ascertained by examination, its quantity must be determined. When such seed as that of trefoil, sweet clover, Canada bluegrass, and other kinds have been used, their separation from all the pure seed of a test sample is laborious and not justified by the information gained. Since the weight of these seeds is approximately the same as that of the seeds with which they are mixed, their relative proportion to pure seed is determined by count. After all other foreign seeds and other materials have been separated from the pure seed and adulterant together 1,000 seeds of the mixed crop seed and adulterant are counted out indiscriminately. This number of seeds is then carefully separated into pure-crop seed and adulterant and the number of each ascertained by actual count. If a sample of red clover seed is found to be adulterated with trefoil to the extent of 400 seeds in 1,000 seeds of the mixture, the trefoil is determined to be 400÷1,000=40 per cent of the mixture. If other foreign matter in the sample amounts to 15 per cent, the clover and trefoil mixture represents 85 per cent of the original sample. The trefoil adulterant therefore amounts to 40 per cent of 85 per cent, or 34 per cent of the seed under test.

Examination of weed seeds.—The weed seeds should be examined for kinds representing important weeds. A knowledge of what important weed seeds are liable to occur in particular kinds of crop seed is very helpful. For this reason the results of many tests are utilized in the subsequent remarks on testing particular kinds of seed. Suspected weed seeds should be carefully compared with the illustrations relating to this class of seeds. Many kinds of weed seeds not illustrated in this bulletin will be found. Most of these, as a rule, are of relatively minor importance.

The germination test.—It is important in separating pure seed for the germination test that the counting be done indiscriminately—without selection as to the appearance of the seed. The tendency of the beginner is to select the more promising-looking seeds for the germination test. It must not be forgotten that the purpose of the test is to learn what percentage of the total pure seed will germinate. If the more promising seed is selected, the results of the test are deceiving in favor of the dealer.

Of small seeds (such as forage crop and cereals), 200 are counted; of larger seeds 100 are taken, each in duplicate. In the special individual ear tests of corn only a few seeds are used. In adulterated samples the necessary number of pure seeds can usually be obtained from the separation of the 1,000 seeds. It is obvious that accurate counting is important to insure accuracy in computing the result.

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[a] See Farmers' Bulletin 382, entitled "The Adulteration of Forage-Plant Seeds."

The conditions essential to seed germination are sufficient moisture, warmth, and air. Sufficient water should be supplied to keep the seeds thoroughly moistened during germination, but they should not be allowed to rest in water. The temperature of living rooms ranging from 65° to 85° F. is suitable for germination. A place in the room should be selected where the day and the night temperatures will be fairly uniform. Thus the window sill is too cold in winter and a shelf directly over the stove is too warm. The germination of some kinds of seeds is favored by the varying day and night temperature of living rooms. Germinating seeds must be supplied with fresh air. If the air is confined, it loses its oxygen, which is necessary to germination, and there is no means for escape of carbon dioxid, a gas produced by the germination process but detrimental to it. A proper covering of cloth, paper, wood, or glass for the seed germinator which prevents too rapid loss of moisture by evaporation, while not hindering the admission of air, should not be neglected. In order to insure sufficient air, very small seeds germinate best on top of the germinator cloth or paper, while larger seeds do better when placed between cloth or paper folds.

When sand or soil is used in testing germination, the seeds should have but a very light covering. Before the sprouts appear the surface of the sand may be kept covered to hold the moisture. Germination in sand and in soil is likely to be somewhat slower than when the test is made in cloth or paper.

Seed in the germinator should be examined daily to note the extent and vigor of germination. Weak, slow germination indicates low vitality, unpromising for good field results in plant production.

Red clover and alfalfa seed are sometimes so slow in absorbing moisture that the germination is delayed several days or even several weeks. This is particularly true of new seed. The same seed a year later may show a greatly reduced amount of this so-called "hard seed" and therefore a higher percentage of germination under test. Such seed remains hard in the test when other seed has become soft by the absorption of water.

The time required for germination differs with different kinds of seed. Between the times of appearance of the first and the last sprouts there is a period of maximum germination when the practical germinating value of the seed is evident.

Determining the actual value of the seed.—The actual value of the pure, germinable seed in a sample depends on its quantity, as compared with the total weight of the sample. Assuming, for illustration, a standard of absolute purity and viability in seed selling at $10 per 100 pounds, such seed is actually worth, at this rate, 10 cents per pound. On the other hand, seed selling at the same price, but on test showing a purity of 80 per cent and viability of 70 per cent, contains but 70 per cent of 80 per cent, or 56 per cent of pure, viable seed. At $10 per 100 pounds of this seed as sold the good seed actually costs nearly 18 cents per pound.

This ideal state of perfection in purity and viability of seed is rarely, if ever, attained. It is important, however, to know the highest quality that seed can justly be expected to show. It is fair that the best seed that is marketed should serve as a guide in this respect, because the average results of miscellaneous tests of any particular kind are too low, since some samples are altogether too low in quality. The fact that seed of the principal forage crops in which both the purity and the viability closely approach 100 per cent does appear on the market justifies one in assuming that all seed of these crops sold as high grade should possess equally good quality.

The practical application of this understanding as to quality may sometimes admit of due allowance. For example, clover seed is sometimes sold locally in the chaff. If such seed is known to be free from noxious weed seeds, it can safely be purchased if proper allowance be made for the proportion of worthless chaff and undeveloped seed. An average sample of the chaffy seed may be weighed and its percentage of good seed ascertained. Since clover seed weighs 60 pounds per bushel, the actual value of such chaffy seed can readily be determined, the price regulated, and the quantity to be sown accurately gauged.

The actual proportion of pure, viable seed in a sample is represented by the product of its percentages of purity and viability expressed in per cent.

TESTING PARTICULAR KINDS OF SEEDS.

GENERAL CONSIDERATIONS.

The work of seed testing is greatly facilitated by a general knowledge of the conditions more or less peculiar to the seed of particular kinds of crops. For illustration, the adulterants used with different kinds of seeds differ in kind; the conditions of culture, of harvesting, and of preparation for market tend to influence the condition of the seed; the kind and source of the seed influence the character of its impurities. Kinds of seed supplied to the market from both domestic and foreign grown stocks should be considered with reference to their source. The significance of the kinds of weed seeds as indicating the source of the seed is at present chiefly applicable to the seed of the clovers and alfalfa.

In the following remarks on the testing of particular kinds of seeds it is assumed that the previously discussed methods of making seed tests in general will be borne in mind, leaving the present discussion to relate chiefly to conditions peculiar to the several kinds of seeds considered. To avoid repetition, it may be stated that for the test sample of clovers, alfalfa, and medium-seeded grasses seed equaling 12½ BB shots in weight may be taken; of the smaller seeded redtop and bluegrasses half this weight, equal to 6¼ BB shots, will suffice; of coarse seeds (as oats, barley, vetch, etc.), double the weight of 12½ BB shots may be used. Several subdivisions of the larger sample may thus be required to segregate the small test sample. A little care will insure accuracy in weighing the test sample.

TESTING RED CLOVER SEED.[a]

The yellow and violet colors of the seed, together with the triangular form of individual seeds, distinguish fresh red clover seed. (See fig. 22.) Old seeds are dull and reddish brown. Imperfectly developed seeds are dull brown and more or less shriveled. Empty perforated seed shells in light screenings show the work of the clover seed chalcis fly.[b] No evidence of the so-called clover seed midge is ever present in seed. Note should be made of the apparent relative quantity of poor true clover seed in the sample.

Consider the matter of intentional adulteration by the use of (1) old red clover seed which is sometimes disguised by oiling and polishing, but which will be disclosed in the germination test; (2) yellow trefoil seed (figs. 3 and 23); and (3) miscellaneous screenings consisting of shriveled clover seed and weed seeds, or of very small red clover seed indicating foreign production.

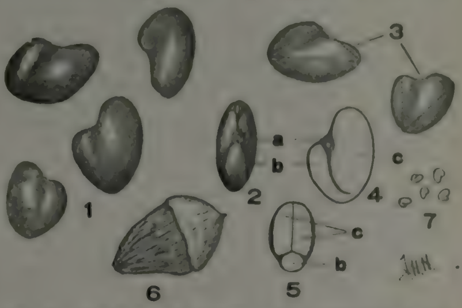

FIG. 22.—Seeds of red clover: **1**, Side view and, **2**, edge view of seeds; **3**, the triangular form indicated; **4**, a seed cut lengthwise; **5**, a seed cut crosswise, showing the embryo; **a**, seed scar; **b**, stemlet (radicle) of the embryo; **c**, seed leaves (cotyledons) of the embryo; **6**, a pod of red clover; **7**, natural size of seeds.

Separate all true red clover seed, together with yellow trefoil present in quantity sufficient to indicate intentional adulteration, from all weed seeds and other materials.

If the sample is adulterated with trefoil or other specific adulterant, count out 1,000 seeds from the clover and adulterant freed from other impurities and determine the quantity of the adulterant by count (p. 30).

The total quantity of true red clover seed, including shriveled seed, is the "pure seed" of the test; accurately record its weight. The percentage of true red clover seed in the test sample and in the original sample is shown by dividing this weight by the weight of the original sample, expressing the result in per cent; or, if seed equal to the weight of 12½ BB shot is being tested, each $\frac{1}{16}$-shot weight represents one-half of 1 per cent of the whole.

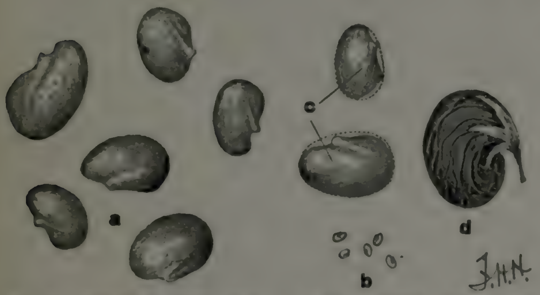

FIG. 23.—Seeds of yellow trefoil: **a**, Seeds showing variation in form and size; **b**, natural size of seeds; **c**, oval form of trefoil seeds indicated; **d**, a pod of trefoil.

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[a] See Farmers' Bulletin 260, entitled "Seed of Red Clover and Its Impurities."

[b] See "Some Insects Affecting the Production of Red Clover Seed," Circular 69, Bureau of Entomology, U. S. Dept. of Agriculture, 1906.

Count indiscriminately from the pure seed 200 seeds in duplicate for the germination test. Conduct this test as previously directed under "The germination test" (p. 30). Sprouting should begin the second day and be completed by the sixth day. At the completion of the sprouting, examine seeds which have not sprouted to determine whether they are hard or soft. In general, the presence of a considerable quantity of hard seed indicates that the sample is one of new seed. The hard seed may amount to 20, 30, or even 50 per cent in red clover seed 1 year old. Although such hard seed is probably all alive, it is practically worthless for seeding. Soft seeds which do not sprout may be considered as dead before the test was made. An excess of such seed indicates the use of old seed as an adulterant.

The best red clover seed tests as high as 98 or 99 per cent purity and 99 per cent viability.

The foreign seeds in red clover may include other crop seeds, as alsike clover, white clover, or timothy. Note should be made of the presence, character, and quantity of such crop seed.

The weed seeds should be considered with respect to their total quantity and their character as affecting the clover crop and the land. Seeds of strictly noxious plants should be distinguished as well as those indicating the domestic or foreign source of the seed. Rural school pupils, especially, who make tests of seeds should be interested in identifying, so far as possible, the kinds of all the weed seeds found.

The noxious weed seeds found in red clover seed include: (Fig. 17) dock (**f**), black bindweed (**g**), Russian thistle (**h**), white campion (**j**), bladder campion (**k**), night-flowering catchfly (**l**), pennycress (**n**), field peppergrass (**o**), two kinds of false flax (**p** and **q**), black mustard (**s**), English charlock (**t**); (fig. 18) Indian mustard (**a**), wild carrot (**d**), field bindweed (**e**), clover dodder (**g**), field dodder (**i**), corn gromwell (**k**), rat-tail plantain (**l**), buckhorn (**m**), ragweed (**n**), wild sunflower (**p**), oxeye daisy (**q**), Canada thistle (**r**), bull thistle (**s**), wild chicory (**t**).

Other weed seeds commonly found in red clover seed include: (Fig. 19) crab-grass (**a**), witch-grass (**b**), yellow foxtail (**c**), green foxtail (**d**), velvet grass (**e**), sedge (**g**), sorrel (**h**), knotweed (**i**), pale knotweed (**j**), lady's-thumb (**k**), lamb's-quarters (**l**), rough amaranth (**n**), spreading amaranth (**o**), wild spurry (**p**), two kinds of chickweed (**q** and **r**), mouse-ear chickweed (**s**), forked catchfly (**t**); (fig. 20) creeping buttercup (**a**), peppergrass (**b**), shepherd's purse (**c**), cinquefoil (**d**), hop clover (**e**), yellow trefoil (**f**), bird's-foot trefoil (**g**), wild geraniums (**h**, **i**, and **j**), stork's-bill (**k**), spurge (**l**), spiny sida (**m**), evening primrose (**n**), red pimpernel (**o**), sticktight (**p**), forget-me-not (**q**), three kinds of vervain (**r**, **s**, and **t**); (fig. 21) catmint (**a**), healall (**b**), rough-leaved toadflax (**c**), smaller broad-leaved plantain (**d**), bracted plantain (**e**), field madder (**g**), cleavers (**h**), wild corn salad (**i**), black-eyed Susan (**l**), dog fennel (**m**), field camomile (**n**), scentless camomile (**o**), cat's-ear (**q**), oxtongue (**r**), hawkweed picris (**s**).

The American or the Canadian origin of red clover seed is strongly indicated by the presence of the following weed seeds: (Fig. 17) night-flowering catchfly (**l**); (fig. 18) field dodder (**i**), rat-tail plantain (**l**), ragweed (**n**), bull thistle (**s**); (fig. 19) witch-grass (**b**), lady's-thumb (**k**), spreading amaranth (**o**); (fig. 20) peppergrass (**b**), cinquefoil (**d**), spurge (**l**), spiny sida (**m**); (fig. 21) bracted plantain (**e**). Seeds of Canada thistle (fig. 18, **r**) or of small-fruited false flax (fig. 17, **q**), if found in abundance, indicate that the source of the seed is Canadian.

European origin of red clover seed is indicated by the presence of certain weed seeds, and the occurrence of several kinds of these in the same sample (especially in the absence of the kinds heretofore mentioned as occurring in American-grown seed), lends weight to the probability of European origin, as follows: (Fig. 18) clover dodder (**g**), wild chicory (**t**); (fig. 19) wild spurry (**p**), chickweed (**q**), forked catchfly (**t**); (fig. 20) bird's-foot trefoil (**g**), wild geraniums (**h**, **i**, and **j**), red pimpernel (**o**), forget-me-not (**q**), vervain (**r**); (fig. 21) field madder (**g**), wild corn salad (**i** and **j**), scentless camomile (**o**), oxtongue (**r**), hawkweed picris (**s**). The presence of a considerable quantity of distinctly small-seeded red clover seed further indicates European origin.

TESTING ALSIKE CLOVER SEED.

Alsike clover seed is distinguished from other kinds by its dark-green color, the small size, and the heart-shaped oval form of individual seeds. The lighter colored seeds are often mottled (fig. 24). Old seed is distinguished from new by the dull, reddish-brown color it acquires.

White clover seed often appearing in alsike seed is distinguished by its yellowish or pinkish color.

Yellow trefoil seed, sometimes used as an adulterant and often present as an incidental impurity, is coarser than the alsike seed and is further distinguishable by its greenish-yellow or brown color and the characteristic form of individual seeds (compare figs. 23 and 24). Adulterants used other than trefoil seed are old alsike seed, timothy seed, and weedy screenings (fig. 8).

Germination proceeds between the second and sixth days of the test, and the viability often attains 99 per cent. Hard seed is less frequently observed in alsike seed than in red clover. The purity commonly amounts to 98 or 99 per cent.

The noxious weed seeds occurring in alsike clover seed include: (Fig. 17) dock (**f**), white campion (**j**), bladder campion (**k**), night-flowering catchfly (**l**), pennycress (**n**), field peppergrass (**o**), small-fruited false flax (**q**), English charlock (**t**); (fig. 18) tumbling mustard (**c**), clover dodder (**g**) very rarely rat-tail plantain (**l**), buckhorn (**m**), ragweed (**n**), oxeye daisy (**q**), and frequently Canada thistle (**r**).

Other common weed seeds in alsike seed include: (Fig. 19) witch-grass (**b**), yellow foxtail (**c**), green foxtail (**d**), velvet grass (**e**), sedge (**g**), sorrel (**h**), knotweed (**i**), lamb's-quarters (**l**), rough amaranth (**n**), spreading amaranth (**o**), wild spurry (**p**), chickweeds (**q** and **r**), mouse-ear chickweed (**s**); (fig. 20) peppergrass (**b**), shepherd's purse (**c**), cinquefoil (**d**), hop clover (**e**), yellow trefoil (**f**), spurge (**l**), evening primrose (**n**), forget-me-not (**q**), vervain (**t**); (fig. 21) catmint (**a**), healall (**b**), smaller broad-leaved plantain (**d**), bracted plantain (**e**), dog fennel (**m**), field camomile (**n**), scentless camomile (**o**).

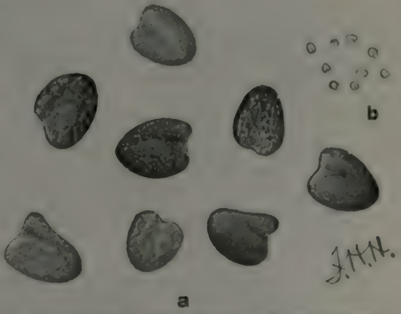

FIG. 24.—Seeds of alsike clover: **a**, Seeds showing variation in form and surface appearance, enlarged; **b**, natural size of seeds.

So little alsike clover seed is imported from Europe that weed seeds indicating European origin of seed are uncommon in this kind of seed. The examination of various samples of European seed shows, however, that the weed seeds found in European red clover seed, previously stated, are essentially the same as those appearing in alsike seed from the same source. Clover dodder (fig. 18, **g**) is particularly noticeable in most of the samples of European alsike clover seed.

TESTING WHITE CLOVER SEED.

White clover seed resembles that of alsike clover in size and form of individual seeds, but the average size is slightly smaller. The light-yellow, pinkish, or light-brown color of white clover seed distinguishes it from the darker alsike. Adulteration is confined chiefly to the use of old seed and of weedy screenings. Much seed imported from Europe is on the American market.

The purity should attain 98 or 99 per cent, the viability 99 per cent; sprouting proceeds from the second to the sixth day.

The noxious weed seeds appearing in white clover seed include: (Fig. 17) dock (**f**), night-flowering catchfly (**l**), pennycress (**n**), false flax (**p** and **q**), English charlock (**t**); (fig. 18) tumbling mustard (**c**), wild carrot (**d**), clover dodder (**g**), rat-tail plantain (**l**), buckhorn (**m**), oxeye daisy (**q**), Canada thistle (**r**).

Other weed seeds commonly appearing in white clover seed are: (Fig. 19) witch-grass (**b**), green foxtail (**d**), velvet grass (**e**), sorrel (**h**), knotweed (**i**), lady's-thumb (**k**), rough amaranth (**n**), wild spurry (**p**), chickweeds (**q** and **r**), mouse-ear chickweed (**s**), forked catchfly (**t**); (fig. 20) peppergrass (**b**), shepherd's purse (**c**), cinquefoil (**d**), hop clover (**e**), yellow trefoil (**f**), wild geraniums (**i**, **j**), red pimpernel (**o**), forget-me-not (**q**), vervain (**t**); (fig. 21) catmint (**a**), healall (**b**), smaller broad-leaved plantain (**d**), field madder (**g**), wild corn salad (**i**), dog fennel (**m**), field camomile (**n**), scentless camomile (**o**), hawkweed picris (**s**).

White clover seed imported from Europe is often infested with most of the kinds of weed seeds enumerated. American-grown seed may carry seeds of (fig. 17) dock (**f**), night-flowering catchfly (**l**), false flax (**q**), English charlock (**t**); (fig. 18) wild carrot (**d**), rat-tail plantain (**l**), buckhorn (**m**), oxeye daisy (**q**); (fig. 19) witch-grass (**b**), green foxtail (**d**), sorrel (**h**), lamb's-quarters (**l**), etc. The absence of seeds usually found only in seed imported from Europe is most suggestive of the domestic origin of white clover seed.

The weed seeds fairly characteristic of European-grown white clover seed, especially when taken collectively, include: (Fig. 18) clover dodder (**g**); (fig. 19) wild spurry (**p**), chickweed (**q**), forked catchfly (**t**); (fig. 20) wild geranium (**i** and **j**), red pimpernel (**o**), forget-me-not (**q**); (fig. 21) field madder (**g**), wild corn salad (**i**), scentless camomile (**o**), hawkweed picris (**s**).

TESTING CRIMSON CLOVER SEED.

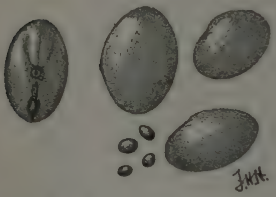

FIG. 25.—Seeds of crimson clover (enlarged and natural size).

The seed of crimson clover is larger than that of the other clovers, the individual seeds being elliptical and so slightly flattened that they roll readily on a flat surface (fig. 25). Fresh seed is pinkish and has a bright luster. As the seed ages it becomes dull and reddish brown. The viability deteriorates rapidly. Adulteration is confined chiefly to the use of old seed, which may usually be distinguished by its color. Considerable trefoil and red clover screenings sometimes appear. Dodder occurs only in lots containing dodder-infested red clover screenings, because the crimson clover is harvested before dodder seed matures.

Most of the crimson clover seed in the American market is imported from Europe. American seed is produced chiefly in Delaware, New Jersey, and Maryland. A white-seeded variety of crimson clover is imported from Europe.

The purity of this seed should be 99 per cent or higher. The viability should be 98 or 99 per cent. Very little hard seed appears in the germination test, which ranges from two to six days in duration.

The noxious weed seeds found in crimson clover seed include: (Fig. 17) chess (**c**),, darnel (**d**), dock (**f**), black bindweed (**g**), corn cockle (**i**), white campion (**j**), bladder campion (**k**), night-flowering catchfly (**l**), pennycress (**n**), field peppergrass (**o**), false flax (**p** and **q**), ball mustard (**r**), black mustard (**s**), English charlock (**t**); (fig. 18) Indian mustard (**a**), hare's-ear mustard (**b**), wild carrot (**d**), clover dodder (**g**), field dodder (**i**), corn gromwell (**k**), rat-tail plantain (**l**), buckhorn (**m**), oxeye daisy (**q**), Canada thistle (**r**), wild chicory (**t**).

Other weed seeds commonly found in crimson clover seed include: (Fig. 19) crab-grass (**a**), witch-grass (**b**), yellow foxtail (**c**), green foxtail (**d**), soft chess (**f**), sorrel (**h**), knotweed (**i**), pale knotweed (**j**), lamb's-quarters (**l**), wild spurry (**p**), chickweeds (**q** and **r**), forked catchfly (**t**); (fig. 20) creeping buttercup (**a**), peppergrass (**b**), shepherd's purse (**c**), hop clover (**e**), yellow trefoil (**f**), bird's-foot trefoil (**g**), three kinds of wild geranium (**h**, **i**, and **j**), stork's-bill (**k**), spurge (**l**), red pimpernel (**o**), forget-me-not (**q**), vervain (**r**); (fig. 21) healall (**b**), rough-leaved toadflax (**c**), smaller broad-leaved plantain (**d**), dwarf plantain (**f**), field madder (**g**), cleavers (**h**), wild corn salad (**i** and **j**), dog fennel (**m**), field camomile (**n**), scentless camomile (**o**), corn flower (**p**), cat's-ear (**q**), hawkweed picris (**s**).

Crimson clover seed of domestic production is often characterized by the presence of one or more of several kinds of weed seeds, some of which are not considered in this bulletin. Two of these kinds, however, are spurge (fig. 20, **l**) and dwarf plantain (fig. 21, **f**). The absence of the kinds given in the following list affords strong indication of domestic production.

The weed seeds especially suggestive of European production include: (Fig. 19) chickweed (**q**), forked catchfly (**t**); (fig. 20) creeping buttercup (**a**), bird's-foot trefoil (**g**), wild geraniums (**h**, **i**, and **j**), red pimpernel (**o**), forget-me-not (**q**), vervain (**r**); (fig. 21) rough-leaved toadflax (**c**), field madder (**g**), wild corn salad (**i** and **j**), scentless camomile (**o**), hawkweed picris (**s**). The presence of white seeds of crimson clover is an additional indication of European production.

TESTING ALFALFA SEED.

Alfalfa seed is distinguishable from the clover seeds by the somewhat variable kidney-shaped form of individual seeds (figs. 2, 4, 5, 6, and 26) and by the greenish-yellow or light-brown color. Old, poorly developed, and shriveled seeds have a dull, reddish-brown color. In general the details of testing red clover seed (p. 33) may be followed in testing alfalfa.

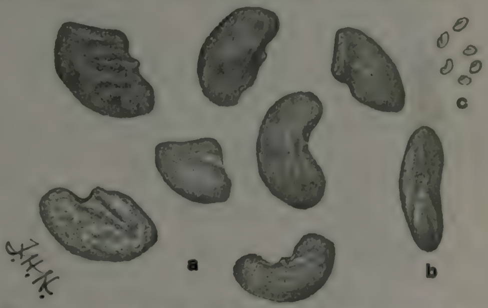

FIG. 26.—Seeds of alfalfa: **a**, Individual seeds, showing variation in form; **b**, edge view of a seed, showing the scar; **c**, natural size of seeds.

Alfalfa seed is adulterated by the use of (1) yellow trefoil (figs. 4 and 23), (2) sweet clover (figs. 5 and 27), (3) bur clover (fig. 6), (4) light, shriveled alfalfa screenings or low-grade, weedy seed.

Besides giving especial attention to the matter of adulteration the question of domestic or of European production should be considered in making the purity test. Much of the seed on the market is imported and the question of domestic or foreign production often can be determined by the weed seeds present.

The purity should attain 98 or 99 per cent, the viability 97 to 99 per cent. The germination test should be completed in six days, most of the seeds sprouting during the second and third days. Considerable hard seed is often found in new seed.

The noxious weed seeds found in alfalfa seed include: (Fig. 17) sand bur (**a**), wild oat (**b**), chess (**c**), quack-grass (**e**), dock (**f**), black bindweed (**g**), Russian thistle (**h**), corn cockle (**i**), white campion (**j**), bladder campion (**k**), night-flowering catchfly (**l**), cow cockle (**m**), pennycress (**n**), field peppergrass (**o**), false flax (**p** and **q**), black mustard (**s**), English charlock (**t**); (fig. 18) Indian mustard (**a**), hare's-ear mustard (**b**), tumbling mustard (**c**), wild carrot (**d**), field bindweed (**e**), clover dodder (**g**), small-seeded alfalfa dodder (**h**), field dodder (**i**), large-seeded alfalfa dodder (**j**), corn gromwell (**k**), rat-tail plantain (**l**), buckhorn (**m**), ragweed (**n**), gumweed (**o**), wild sunflower (**p**), oxeye daisy (**q**), Canada thistle (**r**), bull thistle (**s**), wild chicory (**t**).

Other weed seeds commonly found in alfalfa seed include: (Fig. 19) crab-grass (**a**), witch-grass (**b**), yellow foxtail (**c**), green foxtail (**d**), soft chess (**f**), sorrel (**h**), knotweed (**i**), pale knotweed (**j**), lady's-thumb (**k**), lamb's-quarters (**l**), wild saltbush (**m**), rough amaranth (**n**), spreading amaranth (**o**), wild spurry (**p**), chickweeds (**q** and **r**), mouse-ear chickweed (**s**), forked catchfly (**t**); (fig. 20) creeping buttercup (**a**), peppergrass (**b**), shepherd's purse (**c**), cinquefoil (**d**), hop clover (**e**), yellow trefoil (**f**), bird's-foot trefoil (**g**), wild geraniums (**h**, **i**, and **j**), spiny sida (**m**), evening primrose (**n**), red pimpernel (**o**), sticktight (**p**), vervain (**r**); (fig. 21) catmint (**a**), healall (**b**), rough-leaved toadflax (**c**), smaller broad-leaved plaintain (**d**), bracted plantain (**e**), field madder (**g**), cleavers (**h**), wild corn salad (**i** and **j**), poverty weed (**k**), dog fennel (**m**), field camomile (**n**), scentless camomile (**o**), cornflower (**p**), cat's-ear (**q**), oxtongue (**r**), hawkweed picris (**s**).

The bulk of the domestic alfalfa seed is produced in the Western States and many kinds of weed seeds it carries are distinctly different from those appearing in imported seed. The weed seeds (if not associated with kinds distinctly foreign) pointing decisively to domestic production are: (Fig. 17) sand bur (**a**), Russian thistle (**h**), cow cockle (**i**) fragments; (Fig. 18) tumbling mustard (**c**), small-seeded alfalfa dodder (**h**), the form of field dodder (**i**) having light-colored seeds, large-seeded alfalfa dodder (**j**), ragweed (**n**), gumweed (**o**), wild sunflower (**p**); (fig. 19) wild saltbush (**m**), spreading amaranth (**o**); (fig. 20) spiny sida (**m**); and (fig. 21) poverty weed (**k**).

European origin of alfalfa is indicated by the presence of the following weed seeds: (Fig. 17, white campion (**j**); (fig. 18) wild carrot (**d**), clover dodder (**g**), wild chicory (**t**); (fig. 19) wild spurry (**p**), chickweed (**q**), forked catchfly (**t**); (fig. 20) creeping buttercup (**a**), bird's-foot trefoil (**g**), wild geraniums (**h**, **i**, and **j**), red pimpernel (**o**), vervain (**r**); (fig. 21) rough-leaved toadflax (**c**), field madder (**g**), wild corn salad (**i** and **j**), scentless camomile (**o**), oxtongue (**r**), hawkweed picris (**s**).

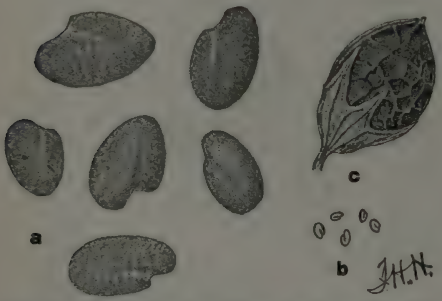

FIG. 27.—Seeds of sweet clover: **a**, Seeds showing variation in form and size; **b**, natural size of seeds; **c**, a pod of sweet clover.

TESTING ORCHARD GRASS SEED.

Orchard grass seed should be carefully mixed before the test sample is taken, because small and relatively heavier impurities are likely to settle to the bottom of the bulk sample. Seed equal to the weight of 12½ BB shots may be taken for the test sample.

Orchard grass seed is readily identified by the slender, pointed form of the seed in the chaff. The lemma of the seed is angled on the back and is curved to one side toward the pointed apex (fig. 10, **a**). The seeds are three-eighths inch to one-half inch long. Some of the seeds bear the sterile chaff of a second seed (middle of fig. 10, **a**).

Orchard grass seed is adulterated by the use of English rye-grass seed, meadow fescue seed, and orchard grass chaff. The seeds of meadow fescue (fig. 10, **b**) and of English rye-grass (fig. 10, **c**) are very similar. They are about the same length as the orchard grass seeds, but are flattened and broader, not curved nor slender pointed. When seen under a magnifier the two kinds may be distinguished by the difference between the rachilla segments, that of meadow fescue being slender, cylindrical, and distinctly expanded at the apex; that of English rye-grass usually wedge shaped, flattened, and scarcely expanded at the apex (fig. 11, **b** and **c**). Both of these kinds of seed often appear as adulterants of the same lot of orchard grass seed. Orchard grass chaff may be distinguished by its light weight, sometimes to some extent by its light color and by the absence of a grain as observed by pressure.

If in making a practical test of orchard grass seed the empty, chaffy seeds freed from other chaffy material are separated from among the grain-bearing seeds the labor is greatly increased. Such chaffy seeds may better be left with the grain-bearing seeds and indiscriminately counted for the germination test, in which the true value will appear. This test requires fourteen days. New, well-cleaned seed should germinate 95 to 98 per cent. The purity should be 98 or 99 per cent.

The noxious weed seeds found in orchard grass include: (Fig. 17) wild oat (**b**), chess (**c**), dock (**f**), including the chaffy covering, black bindweed (**g**), bladder campion (**k**), field peppergrass (**o**); (fig. 18) tumbling mustard (**c**), rat-tail plantain (**l**), buckhorn (**m**), oxeye daisy (**q**).

Other weed seeds commonly found in orchard grass seed include: (Fig. 19) crab-grass (**a**), witch-grass (**b**), velvet grass (**e**), soft chess (**f**), sedge (**g**), sorrel (**h**), lamb's-quarters (**l**), rough amaranth (**n**); (fig. 20) creeping buttercup (**a**), peppergrass (**b**), wild geranium (**i**); (fig. 21) field madder (**g**), cleavers (**h**), scentless camomile (**o**), cat's-ear (**q**).

TESTING MEADOW FESCUE SEED.

Individual meadow fescue seeds are boat-shaped, three-eighths inch to one-half inch long, flattened; the lemma rounded, its apex rather bluntly pointed. The characteristic rachilla segment is slender, cylindrical, and distinctly expanded at the apex (fig. 10, **b**; fig. 11, **b**).

Meadow fescue is often adulterated with seed of English rye-grass, which is almost identical in form but may be distinguished by the rachilla segment which is usually wedge shaped, flattened, and scarcely expanded at the apex (fig. 10, **c**; fig. 11, **c**). The examination of meadow fescue seed for English rye-grass as an adulterant should always be made. The extent of the adulteration may be determined by count from 1,000 seeds of the mixture as previously described.

The seed of chess (fig. 11, **d**) has been used as an adulterant of meadow fescue seed. The chess seeds are larger, usually cylindrically folded, and sometimes have a short awn at the apex. The rachilla segment is curved and club shaped.

Meadow fescue seed usually is comparatively free from meadow fescue chaff, but very poor seed may contain chaff of orchard grass or worthless orchard grass seed. The purity should reach 99 per cent, the viability 95 to 98 per cent.

The noxious weed seeds found in meadow fescue seed include; (Fig. 17) chess (**c**), quack-grass (**e**), dock (**f**), bladder campion (**k**), field peppergrass (**o**), small-fruited false flax (**q**), English charlock (**t**); and buckhorn (fig. 18, **m**).

Other weed seeds found in meadow fescue seed include: (Fig. 19) crab-grass (**a**), witch-grass (**b**), yellow foxtail (**c**), green foxtail (**d**), velvet grass (**e**), soft chess (**f**), sedge (**g**), sorrel (**h**), lady's-thumb (**k**), lamb's-quarters (**l**), wild spurry (**p**); (fig. 20) creeping buttercup (**a**), peppergrass (**b**), yellow trefoil (**f**), forget-me-not (**q**); (fig. 21) bracted plantain (**e**), field madder (**g**), cat's-ear (**q**), hawkweed (**t**).

TESTING TIMOTHY SEED.

Timothy seed is, as a rule, very pure and not subject to adulteration other than by the use of old seed. Tests of this seed are easily made.

After thorough mixing, a quantity of seed equaling the weight of 6¼ BB shots, at least, should be taken for the test sample. Timothy seed is readily identified (fig. 28). It appears both in the chaff (**a**) and as free grains (**b**). Seed in the chaff should have a silvery-white appearance. Free grains are slightly darker and dull. If they are brown a damaged condition is suggested. The purity should be 99 per cent or higher; the viability 98 or 99 per cent. The germination test requires five or six days. In addition to the weed seeds found in timothy some lots contain Kentucky bluegrass seed and Canada bluegrass seed (fig. 9) and alsike clover seed (fig. 24).

The noxious weed seeds found in timothy include: (Fig. 17) dock (**f**), bladder campion (**k**), night-flowering catchfly (**l**), small-fruited false flax (**q**); (fig. 18) rat-tail plantain (**l**), buckhorn (**m**), Canada thistle (**r**). European timothy seed is said to sometimes contain clover dodder (fig. 18, **g**), probably due to its being grown with dodder-infested clover. This dodder does not occur in American or Canadian timothy seed. The most serious impurity is Canada thistle seed found in Canadian-grown timothy.

Other weed seeds occurring in timothy seed include: (Fig. 19) witch-grass (**b**), yellow foxtail (**c**), green foxtail (**d**), sedge (**g**), sorrel (**h**), lady's-thumb (**k**), lamb's-quarters (**l**), mouse-ear chickweed (**s**); (fig. 20) peppergrass (**b**), shepherd's purse (**c**), cinquefoil (**d**), yellow trefoil (**f**), evening primrose (**n**); (fig. 21) catmint (**a**), smaller broad-leaved plantain (**d**), dog fennel (**m**), field camomile (**n**).

TESTING KENTUCKY BLUEGRASS SEED.

The Kentucky bluegrass seed in the American market is produced in this country, chiefly in Kentucky. Seed in bulk has a brownish-straw color. Individual seeds are canoe shaped, approximately three thirty-seconds of an inch long, the back of the lemma being sharply angled. A slender ridge on each side of the angle of the lemma is usually evident (fig. 9, **a**).

The chief points to be considered in testing Kentucky bluegrass seed are the presence of Canada bluegrass seed as an adulterant and the presence of an undue amount of chaff or of dead seed.

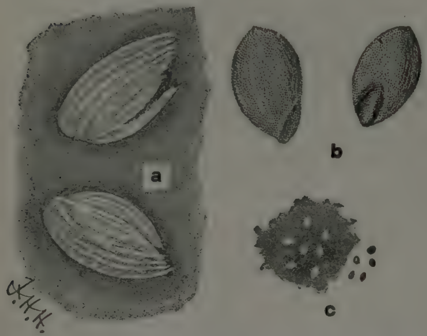

Fig. 28.—Seeds of timothy: **a**, Grains in the hull, or chaff; **b**, grains removed from the chaff; **c**, the same, natural size.

Canada bluegrass seed has been employed in large quantities as an adulterant of or a substitute for Kentucky bluegrass seed. Its seed is very similar to the latter, but can be distinguished by means of a magnifier. In general Canada bluegrass seed in bulk has a somewhat lighter color. Its individual seeds (fig. 9, **b**) are broader, more blunt and papery at the apex, and the sides of the lemma are devoid of the ridges which are distinct in seeds of Kentucky bluegrass seeds (fig. 9, **a** and **b**; fig. 16). The extent of adulteration is determined from 1,000 seeds of the mixture counted indiscriminately.

Since it is difficult to remove all the sterile chaff from seeds containing a grain, it will suffice in making practical tests to remove the lightest chaff, pieces of stems, leaves, etc., as inert matter, endeavoring to leave all the grain-bearing seeds with the pure seed, which by this method will contain also some empty, or sterile, seeds. The pure seed and chaff are separated by placing the weighed sample, a little at a time, on a smooth cardboard tray and pouring it into another tray, allowing the seeds to roll across the face of the tray. The light chaff is held behind, while the heavier grain-bearing seeds roll off. Carefully repeating the operation two or three times effects a very satisfactory separation. After removing the foreign seeds, the seeds (200 in duplicate) for the germination test are to be counted out from the "pure seed" separation, the chaffy and grain-bearing seeds being taken indiscriminately.

Kentucky bluegrass seed should be comparatively free from chaff, but the methods of cleaning in use leave from 10 to 20 per cent or more of chaff with the pure seed. Some samples show the purity ranging from 80 to 85 per cent, but most tests range from 70 to 80 per cent and many fall much lower. The viability ranges from 80 to 90 per cent in the best samples, but most tests range from 65 to 80 per cent and many fall lower. The method of making the purity test given here tends to give higher purity and lower viability than more carefully made official tests. The most of the sprouts appear within nine or ten days, others appearing from time to time until the twenty-eighth day. Only a very light covering, if any, should be placed over the seeds. It is better that they remain uncovered on the cloth or paper if the inverted dish keeps the air about the seeds moist.

The noxious weed seeds found in Kentucky bluegrass seed include: (Fig. 17) dock (**f**), small-fruited false flax (**q**); (fig. 18) corn gromwell (**k**), rat-tail plantain (**l**), buckhorn (**m**), also Canada thistle (**r**) when mixed with Canada bluegrass.

Other weed seeds found in Kentucky bluegrass seed include: (Fig. 19) sedge (**g**), sorrel (**h**), lamb's-quarters (**l**), mouse-ear chickweed (**s**); (fig. 20) peppergrass (**b**), shepherd's purse (**c**), cinquefoil (**d**); (fig. 21) dog fennel (**m**), cat's-ear (**q**), hawkweed (**t**).

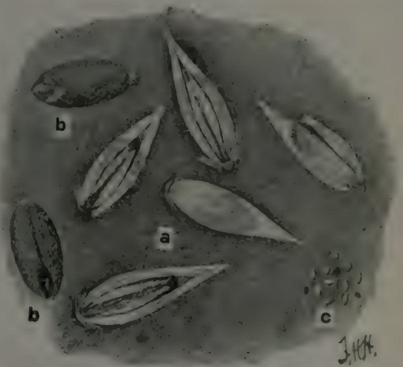

FIG. 29.—Seeds of redtop representing the "fancy" (or "solid") grade of the trade: **a**, Different views of seeds having the white, papery, inner chaff; **b**, two views of a grain, or kernel, with the inner chaff removed; **c**, the same, natural size.

TESTING REDTOP SEED.

In testing redtop seed it should be borne in mind that three grades of this seed are offered in the trade under the names (1) "recleaned" or "solid" seed, (2) "unhulled," and (3) "chaff" seed. The application of these terms becomes evident when the structure of the seed is considered. The recleaned or solid seed consists (fig. 29) of a mixture of free grains (**b**) and grains covered by the silvery, papery inner chaff (**a**). This is the best matured, purest, and heaviest of the grades of redtop. The unhulled grade consists chiefly of seed inclosed in the outer chaff (fig. 30, **a**). This seed is generally more immature than the first grade. It also is lighter and lower in purity than the other. Chaff redtop is a very variable grade consisting largely or almost entirely of empty chaff scales (fig. 30, **a** and **b**) and pieces of stems, leaves, and other inert materials. Many samples of chaff redtop contain very little solid seed.

The recleaned grade is usually comparatively free from impurities, but sometimes contains timothy to the extent of severe adulteration and so should be tested in this respect.

In making a practical test of the unhulled and chaff grades of redtop the lightest chaff may be blown carefully from the heaviest seed of a quantity of seed of known weight. Some seeds will retain the inclosing outer chaff, giving them the appearance shown in figure 30, **a**. Slight rubbing will loosen this outer chaff, when it, too, may be blown away, leaving the pure seed in essentially the same condition as shown in the recleaned grade. This seed, after removing the ergot, timothy, and other foreign seeds, may then be weighed and its quantity compared with the quantity of the original test sample. Such a comparison sometimes shows a surprisingly small quantity of true seed in chaffy grades.

The purity of commercial redtop seed is evidently dependent on the trade grade and the extent to which the grades are cleaned. The solid or recleaned grade should show a purity of 95 to 98 per cent. The germination should be as high. The unhulled grade is more variable both as to purity and viability. The purity is influenced by the widely variable quantity of broken leaves, ergot, and loose chaff, and the viability varies because of the practically worthless immature and undeveloped grains which constitute a variable proportion of this grade of seed.

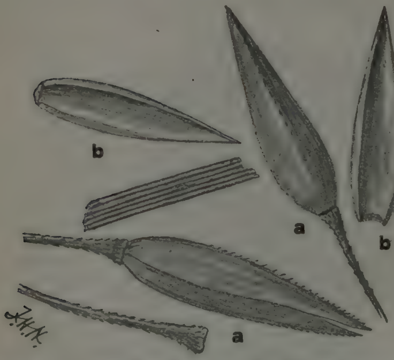

FIG. 30.—Chaff of redtop seed: **a**, Whole spikelets usually devoid of seed in "chaffy" grades; **b**, separated scales of the same; **a** and **b** represent the outer chaff of the seed. (Enlarged.)

The noxious weed seeds found in redtop (chiefly in the chaffy grades, include: (Fig. 17) dock (**f**); (fig. 18) tumbling mustard (**c**), rat-tail plantain (**l**), buckhorn (**m**), oxeye daisy (**q**).

The commoner of the other weed seeds found in redtop seed include: (Fig. 19) crab-grass (**a**), witch-grass (**b**), sedge (**g**), lamb's-quarters (**l**), chickweed (**r**); (fig. 20) peppergrass (**b**), shepherd's purse (**c**), cinquefoil (**d**); (fig. 21) black-eyed Susan (**l**), dog fennel (**m**), field camomile (**n**).

TESTING AWNLESS BROME-GRASS SEED.

Both domestic and imported seed of awnless brome-grass (*Bromus inermis*) is in the American market. This seed should be readily recognized by its large size and thin, boat-shaped form and the light-brown color of the individual seeds. The large, thin, dark-brown grain of the seed is easily distinguished through the papery palea (fig. 11, **a**).

Adulteration of awnless brome-grass seed consists in the use of seed of meadow fescue and of English rye-grass (fig. 11, **b** and **c**.) The seed of chess, or cheat, sometimes passes in the trade as awnless brome-grass seed. These two kinds of seed are closely related botanically, but they are readily distinguishable under careful observation (fig. 11, **a** and **d**).

One objection to the use of brome-grass seed imported from Europe is that it carries the seed of quack-grass (fig. 17, **e**). Unfortunately in respect to popular seed testing, awnless brome-grass seed produced in the Northwestern States and in Canada may carry seed of wheat-grass which is so similar to that of quack-grass that the layman is not likely to distinguish them with certainty.[a]

The number of kinds of weed seeds carried by awnless brome-grass seed is comparatively small, but some of them are very undesirable.

Awnless brome-grass seed should show purity of 98 or 99 per cent and viability of 90 to 95 per cent in fourteen days.

The noxious weed seeds found in this seed include: (Fig. 17) wild oat (**b**), chess (**c**), quack-grass (**e**), black bindweed (**g**), pennycress (**n**), field peppergrass (**o**), large-fruited false flax (**p**); and field bindweed (fig. 18, **e**).

Other weed seeds sometimes appearing in awnless brome-grass seed include: (Fig. 19) soft chess (**f**), lady's-thumb (**k**), lamb's-quarters (**l**), rough amaranth (**n**); (fig. 20) yellow trefoil (**f**), sticktight (**p**); and cleavers (fig. 21, **h**).

European origin of awnless brome-grass seed is strongly suggested by the presence of seeds of quack-grass (fig. 17, **e**), false flax (fig. 17, **p**), field bindweed (fig. 18, **e**), and soft chess (fig. 19, **f**).

TESTING SEED OF MILLETS.

The millets used as forage crops in this country represent three distinct kinds of grasses—the broom-corn, or grain, millets (fig. 31, **a**), the foxtail millets (German, common, and Hungarian; fig. 31, **b**), and the barnyard and Japanese millets (fig. 31, **c**). The seed test should show which kind is involved.

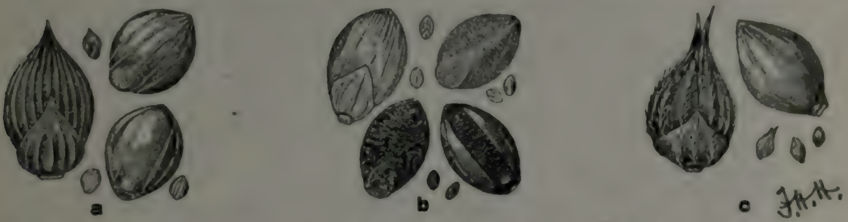

FIG. 31.—Seeds representing the three groups of millets: **a**, Broom-corn millet; **b**, foxtail millets, including the German, common, and Hungarian varieties; **c**, barnyard and Japanese millets. (Enlarged and natural size.)

Seeds of the broom-corn millets (fig. 31, **a**) are mostly free from the brown, papery, loose-fitting chaff; they are broadly oval, robust, highly polished, shining, and tend to roll readily on a plane surface. The color varies in different varieties and includes straw-color, light yellow, orange, gray, and dark brown.

Seed of the foxtail millets (fig. 31, **b**) appears both with and without the thin, whitish, outer chaff, most of the seeds being free from it. With the outer chaff removed, the seeds present a finely roughened, or stippled, surface which has a slight luster. German millet seeds usually are broadly oval, robust; they roll readily and are commonly orange colored. Common millet seeds are oval, but relatively longer in proportion to their width than seeds of German millet; yellowish or greenish in color. Hungarian millet seed consists of a mixture of yellow or golden colored seeds and of dark-purple seeds. The darker seeds are often mottled. Seeds of the foxtail millets, particularly those of common millet, are distinguishable from the similar seeds of the weed, green foxtail (fig. 19, **d**), by their slightly larger size and more polished surface.

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[a] Circular No. 73 of the Bureau of Plant Industry points out the distinguishing characters of the seeds of quack-grass, slender wheat-grass, and western wheat-grass.

Seed of barnyard millet including that of Japanese millet (fig. 31, **c**) is chiefly inclosed in the light-brown or dark-brown, hairy, sharp-pointed outer chaff. With this chaff removed, the seed is oval, whitish or gray, smooth, and polished, plano-convex, the convex face strongly arched (fig. 31, **c**).

The purity of all the millets should reach 99 per cent, the viability 95 per cent or higher in three to five days.

Much of the seed of all the millets used in this country, excepting possibly the common barnyard millet, is imported, and many kinds of injurious weeds are thus introduced. This is particularly true of the broom-corn and foxtail millets. About the same kinds of weed seeds are carried by each.

The noxious weed seeds found in broom-corn millet include: (Fig. 17) dock (**f**), black bindweed (**g**), corn cockle (**i**), night-flowering catchfly (**l**), cow cockle (**m**), pennycress (**n**), ball mustard (**r**), English charlock (**t**); (fig. 18) Indian mustard (**a**), hare's-ear mustard (**b**), tumbling mustard (**c**), field bindweed (**e**), corn gromwell (**k**), rat-tail plantain (**l**), buckhorn (**m**), wild sunflower (**p**), Canada thistle (**r**), wild chicory (**t**).

Other weed seeds commonly found in broom-corn millet include: (Fig. 19) crab-grass (**a**), yellow foxtail (**c**), green foxtail (**d**), soft chess (**f**), sorrel (**h**), knotweed (**i**), pale knotweed (**j**), lady's-thumb (**k**), lamb's-quarters (**l**), rough amaranth (**n**), spreading amaranth (**o**), wild spurry (**p**); (fig. 20) creeping buttercup (**a**), red pimpernel (**o**), sticktight (**p**), vervain (**r**); (fig. 21) healall (**b**), cleavers (**h**), dog fennel (**m**), field camomile (**n**).

TESTING SEED WHEAT.

A practical test of seed wheat may be made in which the points to be considered are the quantity of shriveled, or "pinched," grains, the presence of bunt, the quantity and character of the weed seeds, and the viability of the plump grains.

After thorough mixing of the bulk sample, a quantity of seed equaling the weight of 12½ or even 25 BB shots may be taken for the test sample. This should be separated into plump, well-filled, large grains and shriveled, small grains.

While making this separation the presence or absence of bunt, or diseased grains, should be noted. Such grains are somewhat above the average size of the best grains, brown in color, soft, and show a blackened interior when broken open. Seed fit for sowing should be plump and well filled; it should show at least 99 per cent purity and 99 per cent viability in three days and be free from bunt.

The noxious weed seeds found in wheat include: (Fig. 17) wild oat (**b**), chess (**c**), darnel (**d**), quack-grass (**e**), dock (**f**), black bindweed (**g**), Russian thistle (**h**), corn cockle (**i**), cow cockle (**m**), pennycress (**n**), field peppergrass (**o**), false flax (**p**), ball mustard (**r**), black mustard (**s**), English charlock (**t**); (fig. 18) Indian mustard (**a**), hare's-ear mustard (**b**), tumbling mustard (**c**), field bindweed (**e**), corn gromwell (**k**), ragweed (**n**), the similar (but larger) seeds of giant ragweed, wild sunflower (**p**), Canada thistle (**r**), bull thistle (**s**), and the whitish or pinkish bulblets of wild garlic which are sometimes very abundant in wheat grown in the Eastern States.

Other weed seeds occurring in wheat include many of those found in forage-crop seeds. This is particularly true of wheat which has been poorly cleaned.

A test of a poor grade of wheat along the lines suggested should convince any farmer of the value of the fanning mills and suitable screens used in grading seed wheat.

TESTING SEED OATS AND BARLEY.

Seed of oats and barley may be tested in general as outlined for wheat. In testing oats especial attention should be given to the possible presence of seed of wild oat (fig. 17, **b**), which can be recognized by its brown color, the brown hairs at the base of the seed, the bent awn at the back, and especially by the expanded, cup-shaped scar at the base of the seed.

The purity of oats and barley should reach 99 per cent, the viability at least 95 per cent for oats and 98 or 99 per cent for barley.

In general the weed seeds appearing in wheat may be expected to appear in poorly cleaned oats and barley.

TESTING FLAX SEED.

Properly cleaned flax seed should be practically free from impurities, thus showing a purity of nearly 100 per cent. The viability should reach 99 per cent or higher in two or three days. Both domestic and imported seed are in the market. Poorly cleaned grades contain many kinds of weed seeds which, in general, include most of those found in millet seed and in wheat. In a test of flax seed especial attention should be given to the discovery of seed of flax dodder. As shown in figure 12, some of these dodder seeds are double and thus fail to pass a sieve which will remove most of the single seeds. Fairly well-cleaned lots of flax seed are thus likely to contain these double seeds of dodder. Much of the imported flax seed contains seed of flax dodder. The very destructive nature of this dodder justifies every effort to prevent the introduction of its seed. Seed of false flax (fig. 17, **p**) is a common noxious impurity which should be avoided.

TESTING WINTER RAPE SEED.

Popular tests of rape seed are not likely to be wholly satisfactory because of the difficulty in identifying with certainty the seeds of the different kinds of rape and the closely allied mustard weeds. Seed of the more important winter, or Essex, rape may generally be recognized by the relatively large size of the individual seeds (somewhat larger than those of summer rape or of turnip), by their steel-black color, and their roundness, allowing them to roll readily on a plane surface. Summer rape seeds are mostly smaller, consisting of a mixture of black and reddish seeds, some of the black seeds being distinctly pitted, or nearly all the seeds reddish. Some lots of seed, particularly of summer rape, are adulterated with seed of English charlock (fig. 17, **t**). As a rule the charlock seeds may be distinguished by their smaller size, more nearly spherical form, their smoother surface and by the presence of mature reddish or brown seeds with the black ones. Some lots of rape seed are heavily adulterated with seed of Indian mustard (fig. 18, **a**). These seeds are readily recognized by their uniformly reddish-brown color and by the netted or pitted surface as seen under a magnifier. The purity of winter rape should be 99 per cent or higher, the viability as high under a test of two or three days' duration. A miscellaneous series of weed seeds, most of which are previously described and figured, is likely to appear in poorly cleaned grades of rape seed, particularly the summer variety.

TESTING VETCH SEED.

A popular test of vetch seed consists chiefly in distinguishing the seed of hairy (winter) vetch and that of spring vetch, and determining the viability.

Winter vetch seed (fig. 32, **a**) consists of nearly spherical, steel-black seeds showing some variation in size. The seed is distinguished from other kinds by its characteristic seed-scar which is oblong-oval with a whitish slit through the center. A small protuberance (the chalaza) of the seed coat is located nearly the length of the scar distant from the narrower end of the scar, as shown in the figure.

Seeds of spring vetch represent several varieties and thus are variable in size, form, and surface. The characteristic scar is wedge shaped with a slender, black slit through its center, the slightly raised margins of the slit usually being light colored. The usually distinct chalaza, as a rule, is about half the length of the scar distant from the narrower end of the scar (fig. 32, **b**). Some seeds of spring vetch are large, compressed, and somewhat angular; others are nearly spherical and smaller. The surface is black, brown, gray, or mottled. In one variety, a common impurity of winter vetch seed, the seeds are spherical, jet-black, and about the size of the smaller winter vetch seeds. Only careful examination under a magnifier discloses their darker color and characteristic scar in which, however, the margins of the scar slit are black. In testing seed of winter vetch the seeds of this variety of spring vetch should be sought especially. Seeds of other varieties of spring vetch are usually distinguishable from winter vetch seeds by their different form or color.

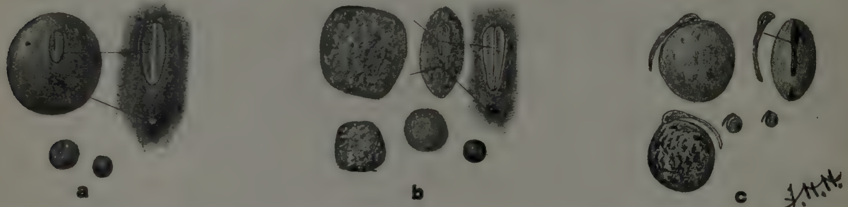

FIG. 32. Seeds of three kinds of vetch; **a**, Winter (or hairy) vetch; **b**, spring vetch; **c**, wild vetch (*Vicia hirsuta*). (Enlarged and natural size.)

Various weed seeds, mostly of the class appearing in seed of millets and cereal grains, are sometimes present in poorly cleaned vetch seed. The seed of a wild species of vetch (*Vicia hirsuta* (L.) Koch, fig. 32, **c**) is a common impurity of cultivated vetch seed.

Vetch seed should show nearly 100 per cent purity. The viability of commercial seed is variable and is strongly influenced by the hard seed, especially in the case of winter vetch in which the hard seed may amount to 30 per cent or more. In spring vetch the hard seed usually varies between 5 and 15 per cent. The sprouting of the hard seed is hastened in the test by cutting through the seed coat with a knife blade, thus admitting moisture. The coat should not be cut in the vicinity of the seed scar lest the embryo be injured.

The germinable seed in high-grade lots of commercial winter vetch seed, together with the variable quantity of hard seed, ranges from

95 to 98 per cent. Some lots germinate between the second and sixth days; others during the second week of the test.

In spring vetch viability of 95 to 98 per cent is less commonly reduced by the hard seed. Sprouting takes place chiefly between the third and fifth days.

TESTING SEED CORN.

The testing of seed corn so far as it corresponds to the tests applied to seed of other crops consists chiefly of the germination test, showing how much of the seed will germinate and with what vigor. Assuming that the corn to be used for seed is in the ear and has been selected with reference to variety and in conformity with the recognized type of ear and of kernel best adapted for crop production, it remains to test its viability.

The two types of germinator adapted for this work have already been referred to (p. 14). After removing sufficient of the butt and tip kernels of the ear to leave on the cob kernels of uniform size, 6 kernels are removed for test. Of these, 2 are taken from near the butt, 2 from the middle, and 2 from near the tip. Each pair of kernels should be taken from opposite rows, these rows being one-third of the circumference of the ear apart. In this way fairly representative kernels of the ear are chosen. The kernels are placed side by side, germ side uppermost, in the marked squares of the germinator which are numbered serially, the ears furnishing the kernels for the squares being numbered correspondingly. This is an individual ear test. Every seed should germinate, thus showing viability of 100 per cent. If any of the kernels of an ear fail to germinate, that ear should be discarded. If the germination for any ear is weak, producing inferior sprouts or is unduly slow, the ear should be rejected. The character of the sprouting should be apparent in five days.

SUMMARY.

(1) It is important that farm seeds be tested before they are sown.

(2) Seed testing in its essential features giving practical results can be done more easily than is generally believed.

(3) By means of a seed test the actual value of seed in question as compared with seed of the best quality can be determined and damage to the crop or the land due to noxious weed seeds can be avoided.

(4) Practical seed tests can be made with simple equipment by anyone interested in the purchase or use of seeds.

(5) It is readily possible for the farmer to make practical tests of seeds, thereby safeguarding against partial or complete loss of crops.

(6) Seed testing is admirably adapted for practical exercise work in elementary agriculture in rural schools.

(7) The essential preparation for making seed tests consists of providing the simple apparatus necessary and of becoming familiar with the general purposes and methods of testing and the features of importance peculiar to tests of particular kinds of seeds.

O

Issued February 16, 1911.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 429.
[Superseding 268.]

INDUSTRIAL ALCOHOL:
SOURCES AND MANUFACTURE.

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WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Chemistry,
Washington, D. C., October 26, 1910.

Sir: This report constitutes the second revision of a bulletin on industrial alcohol (No. 268) first issued in 1906 and slightly revised in 1907. Its object is to furnish concise and authoritative information regarding the sources and the general processes of manufacture of denatured alcohol, in response to the many inquiries addressed to the department on this subject. It embodies most of the material contained in the earlier editions, together with the results of later work the scientific details of which are given in Bulletin 130 of the Bureau of Chemistry, entitled "The Manufacture of Denatured Alcohol." Farmers' Bulletin 410, on "Potato Culls as a Source of Industrial Alcohol," contains more specific information as to the methods of manufacturing industrial alcohol from this and other wastes. I recommend the publication of the manuscript herewith as a new Farmers' Bulletin superseding No. 268.

Respectfully,

H. W. Wiley,
Chief, Bureau of Chemistry.

Hon. James Wilson,
Secretary of Agriculture.

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INDUSTRIAL ALCOHOL: SOURCES AND MANUFACTURE.

ALCOHOL AND DENATURED ALCOHOL DEFINED.

ALCOHOL.

The term alcohol, as used herein, signifies that particular product which is obtained by the fermentation and distillation of solutions of sugar, and which is known to chemists as "ethyl alcohol." It is a colorless and mobile liquid which has a peculiar "spirituous" odor and a sharp and burning taste. When it is left in a crude condition, both its odor and its flavor are rendered somewhat disagreeable by impurities which originate in the earlier stages of manufacture; but when it has been purified thoroughly—in which state it is commonly known as "neutral" or "cologne" spirit—it acquires a distinctly agreeable smell. It mixes freely with water, in all proportions; and, as is well known, it is the essential intoxicating ingredient of all the fermented and distilled liquors. When "strong," or nearly free of water, it dissolves gums and resins very readily, and burns with an intensely hot, pale-blue flame. Because of these characteristics it is used in large amounts in the preparation of certain varnishes, and as a fuel in cases where its cleanliness, intense heat, and freedom from danger of explosion, offset its expensiveness. Alcohol boils at a much lower temperature than water, and it is this fact that makes it possible to separate it, by distillation, from the aqueous solutions in which it originally is formed. Bulk for bulk, it is considerably lighter than water, and mixtures of alcohol and water show fairly regular increases in weight, per unit of volume, in proportion to the percentages of water which they contain. Because of this relation the alcoholic strength of any such mixture can be determined by means of an appropriately graduated alcoholometer. The strength of alcohol solutions may be stated in percentages by volume or by weight, or in United States proof degrees, one such degree corresponding to one-half of 1 per cent of alcohol by volume.

Chemists employ the formula C_2H_5OH to denote the composition of alcohol. This signifies that one molecule, or unit, of the compound substance alcohol is made up of two atoms, or units, of the element carbon (written C), six atoms of the element hydrogen (written H), and one atom of the element oxygen (written O). The percentage composition of alcohol is—carbon (C) 52.12 per cent, hydrogen (H) 13.13 per cent, and oxygen (O) 34.75 per cent.

DENATURED ALCOHOL.

On account of the intoxicating powers of alcohol, its manufacture is prohibited in many communities, and throughout nearly all of the civilized world its production is hedged about with restrictions in the form of excise laws, which, in addition to producing revenue, raise its price to the consumer and tend to diminish its consumption in the form of beverages. However, this increase in cost, due to tax imposition, interferes seriously with the use of alcohol for fuel and for many other legitimate industrial purposes; and therefore many governments have enacted laws which authorize its manufacture, sale, and use, for industrial ends, tax free, upon the condition that it shall first be made unfit for beverage use by the addition of materials which will give it a thoroughly foreign and nauseating odor and taste without making it dangerously poisonous or interfering with the particular industrial purpose for which it is intended. Alcohol which thus has been made unfit for drinking, is called "denatured alcohol." The materials which are used to make it unpotable, whatever their particular nature, are called "denaturants," and the process by which they are dissolved in or mingled with the original potable alcohol is called "denaturing." Some of these materials and the methods of their employment are discussed on page 9.

THE DENATURED ALCOHOL LAW.

On June 7, 1906, an act of Congress was approved which provided for the withdrawal from bond, tax free, of domestic alcohol when rendered unfit for use as a beverage or as an ingredient of medicines by mixture with suitable denaturing materials. The act reads in part as follows:

> *Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled*, That from and after January first, nineteen hundred and seven, domestic alcohol of such degree of proof as may be prescribed by the Commissioner of Internal Revenue, and approved by the Secretary of the Treasury, may be withdrawn from bond without the payment of internal-revenue tax, for use in the arts and industries, and for fuel, light, and power, provided said alcohol shall have been mixed in the presence and under the direction of an authorized Government officer, after withdrawal from the distillery warehouse, with methyl alcohol or other denaturing material or materials, or admixture of the same, suitable to the use for which the alcohol is withdrawn but which destroys its character as a beverage and renders it unfit for liquid medicinal purposes; such denaturing to be done upon the application of any registered distillery in denaturing bonded warehouses specially designated or set apart for denaturing purposes only, and under conditions prescribed by the Commissioner of Internal Revenue with the approval of the Secretary of the Treasury.
>
> The character and quantity of the said denaturing material and the conditions upon which said alcohol may be withdrawn free of tax shall be prescribed by the Commissioner of Internal Revenue, who shall, with the approval of the Secretary of the Treasury, make all necessary regulations for carrying into effect the provisions of this act.

Distillers, manufacturers, dealers, and all other persons furnishing, handling, or using alcohol withdrawn from bond under the provisions of this act shall keep such books and records, execute such bonds and render such returns as the Commissioner of Internal Revenue, with the approval of the Secretary of the Treasury, may by regulation require.

Such books and records shall be open at all times to the inspection of any internal-revenue officer or agent.

SEC. 2. That any person who withdraws alcohol free of tax under the provisions of this act and regulations made in pursuance thereof, and who removes or conceals same, or is concerned in removing, depositing, or concealing same for the purpose of preventing the same from being denatured under governmental supervision, and any person who uses alcohol withdrawn from bond under the provisions of section one of this act for manufacturing any beverage or liquid medicinal preparation, or knowingly sells any beverage or liquid medicinal preparation made in whole or in part from such alcohol, or knowingly violates any of the provisions of this act, or who shall recover or attempt to recover by redistillation or by any other process or means, any alcohol rendered unfit for beverage or liquid medicinal purposes under the provisions of this act, or who knowingly uses, sells, conceals, or otherwise disposes of alcohol so recovered or redistilled, shall on conviction of each offense be fined not more than five thousand dollars, or be imprisoned not more than five years, or both, and shall, in addition, forfeit to the United States all personal property used in connection with his business, together with the buildings and lots or parcels of ground constituting the premises on which said unlawful acts are performed or permitted to be performed: *Provided*, That manufacturers employing processes in which alcohol, used free of tax under the provisions of this act, is expressed or evaporated from the articles manufactured, shall be permitted to recover such alcohol and to have such alcohol restored to a condition suitable solely for reuse in manufacturing processes under such regulations as the Commissioner of Internal Revenue, with the approval of the Secretary of the Treasury, shall prescribe. * * *

It will be seen that this law provided only for denaturing such alcohol as had been made in distilleries subject to the full regulations of the Bureau of Internal Revenue[1] and deposited in the warehouses of such distilleries. Contrary to general expectation, it did nothing toward facilitating manufacture on a small scale in such agricultural distilleries as are operated very generally in Europe. However, in the following year an amendatory act was passed (approved March 2, 1907) which was intended in part to remedy this defect in the original law. The text of this amendment is as follows:

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That notwithstanding anything contained in the act entitled "An act for the withdrawal from bond tax free of domestic alcohol when rendered unfit for beverage or liquid medicinal uses by mixture with suitable denaturing materials," approved June seventh, nineteen hundred and six, domestic alcohol when suitably denatured may be withdrawn from bond without the payment of internal-revenue tax and used in the manufacture of ether and chloroform and other definite chemical substances where said alcohol is changed into some other chemical substance and does not appear in the finished product as alcohol: *Provided*, That rum of not less than one hundred and fifty degrees proof may be withdrawn, for denaturation only, in accordance with the provisions of said act of June seventh, nineteen hundred and six, and in accordance with the provisions of this act.

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[1] Regulations and instructions concerning the tax on distilled spirits. United States Internal Revenue. No. 7, revised.

SEC. 2. That the Commissioner of Internal Revenue, with the approval of the Secretary of the Treasury, may authorize the establishment of central denaturing bonded warehouses, other than those at distilleries, to which alcohol of the required proof may be transferred from distilleries or distillery bonded warehouses without the payment of internal-revenue tax, and in which such alcohol may be stored and denatured. The establishment, operation, and custody of such warehouses shall be under such regulations and upon the execution of such bonds as the Commissioner of Internal Revenue, with the approval of the Secretary of the Treasury, may prescribe.

SEC. 3. That alcohol of the required proof may be drawn off, for denaturation only, from receiving cisterns in the cistern room of any distillery for transfer by pipes direct to any denaturing bonded warehouse on the distillery premises or to closed metal storage tanks situated in the distillery bonded warehouse, or from such storage tanks to any denaturing bonded warehouse on the distillery premises, and denatured alcohol may also be transported from the denaturing bonded warehouse, in such manner and by means of such packages, tanks or tank cars, and on the execution of such bonds, and under such regulations as the Commissioner of Internal Revenue, with the approval of the Secretary of the Treasury, may prescribe. And further, alcohol to be denatured may be withdrawn without the payment of internal-revenue tax from the distillery bonded warehouse for shipment to central denaturing plants in such packages, tanks and tank cars, under such regulations, and on the execution of such bonds as may be prescribed by the Commissioner of Internal Revenue, with the approval of the Secretary of the Treasury.

SEC. 4. That at distilleries producing alcohol from any substance whatever, for denaturation only, and having a daily spirit-producing capacity of not exceeding one hundred proof gallons, the use of cisterns or tanks of such size and construction as may be deemed expedient may be permitted in lieu of distillery bonded warehouses, and the production, storage, the manner and process of denaturing on the distillery premises the alcohol produced, and transportation of such alcohol, and the operation of such distilleries shall be upon the execution of such bonds and under such regulations as the Commissioner of Internal Revenue, with the approval of the Secretary of the Treasury, may prescribe, and such distilleries may by such regulations be exempted from such provisions of the existing laws relating to distilleries as may be deemed expedient by said officials.

SEC. 5. That the provisions of this act shall take effect on September first, nineteen hundred and seven.

This amendment in effect created a class of distilleries in which alcohol may be made for denaturation only, in quantities not exceeding 100 proof gallons daily. In accordance with its provisions, revised regulations were issued by the Bureau of Internal Revenue on July 7, 1907,[1] which interpret the law very liberally, relieving such small distilleries of many restrictions placed upon the operation of larger establishments and making it possible to produce denatured alcohol on a small scale, provided that the economic conditions prevailing in any given locality are such as to make this production profitable. Further reference to the substance of these regulations is made on page 30.

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[1] Regulations and instructions concerning denatured alcohol, etc. United States Internal Revenue Regulations No. 30, Revised.

DENATURANTS AND DENATURING.

In order to insure the use of suitable materials for denaturing, the law authorizes the Commissioner of Internal Revenue to prescribe the character of the denaturing materials and the manner in which they shall be employed; and in accordance with this provision a list of denaturants for both general and special purposes has been issued, giving directions for their use and tests for determining their quality or fitness for such use.[1] Among the substances mentioned therein are the following: Wood alcohol, benzin, pyridin bases, camphor, castor oil, caustic soda, nicotin, ether, and acetone.

Indiscriminate use of these materials is not allowed. Most of them are to be used only in the manufacture of "specially denatured alcohol," the sale and use of which are permitted only under special restrictions. In making "completely denatured alcohol," the variety which may be bought freely by the public at druggists' and paint shops, only wood alcohol, benzin, and pyridin may be used. On account of the relatively high price of the pyridin bases, and of the fact that the specifications for "approved benzin" admit the use of an inexpensive petroleum distillate, the following formula is altogether employed at present in making completely denatured alcohol in the United States:

> To every 100 parts by volume of ethyl alcohol of the desired proof (not less than 180°) there shall be added 10 parts by volume of approved methyl alcohol and one-half of 1 part of approved benzin.

It is prescribed in the internal-revenue regulations that every industrial distillery of the class herein considered must have a special alcohol room with cisterns for storing the product of the distillery. In case the distiller intends to denature this product on the distillery premises, he is obliged also to furnish this room with the following apparatus: A weighing tank, which is to be used for gauging alcohol and for no other purpose; tanks for the storage of approved denaturants; sealed measures, for use with the denaturants; a mixing tank, and, if desired, tanks for the storage of denatured alcohol. The labor required in denaturing is furnished by the distiller and his employees, but is carried on under the supervision of a United States gauger assigned for the purpose and in his immediate presence.

MATERIALS WHICH MAY SERVE AS SOURCES OF ALCOHOL.

GENERAL CONSIDERATIONS.

The first essential in the character of a material which is to serve as a source of alcohol is that it shall contain either fermentable sugar or some component which can be transformed readily into a fermentable sugar. This is absolutely necessary, as without sugar no alcohol can be produced. A second essential is that the proportion of sugar, or its equivalent, in the proposed raw material, shall be sufficient to pay for handling the latter. This is very important, for there are many saccharine materials, such as tomatoes and unripe watermelons, the juices of which contain so small a percentage of sugar that all the alcohol obtained would be insufficient to pay for the mere cost of handling. A third requisite is that there shall be an abundant, concentrated, and stable supply of the material. Abundance is an essential, because even a small distillery will use a large amount of material daily. Thus, a plant having an approximate daily capacity of 100 gallons, or two barrels of denatured alcohol, will consume the following amounts of raw material: 200 gallons of rich molasses; or 1 ton of shelled corn; or 4 tons of potatoes, containing about 15 per cent of starch; or 7 to 8 tons of sweet apples, containing about 12 per cent of sugar. A concentrated supply of material is necessary, for if it be scattered over a wide area and must be gathered by hand, the cost for labor becomes prohibitive. The supply must be constant, for it does not pay to build a factory that can be run only at intervals. For example, ripe peaches would undoubtedly be worth distilling in localities where they are grown abundantly and where there are surplus crops, if it were not for the fact that there may not be a surplus more than two years out of five, and that the crop would have to be worked up within the short space of two or three weeks to keep it from spoiling. No distillery could earn the interest on its investment running two months out of five years.

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[1] United States Internal Revenue, Regulations No. 30, Rev., pp. 23-26 and 115-117.

In addition to the points enumerated, other considerations present themselves: Whether the material in question will stand transportation and storage; whether it can be worked with appliances which are to be obtained readily in this country; whether it can be handled by the machinery which is adapted to the bulk of the available material in any given region, or must have special machinery installed to fit it for fermentation; whether it possibly may yield a greater profit if used for some other purpose than distilling, and so on.

CHEMICAL COMPOSITION OF FERMENTABLE MATERIALS.

Knowledge of the chemical composition of a proposed raw material is always essential in determining its availability as a source of alcohol. The proportion of sugar or other fermentable substance which may be present has been mentioned already as being of prime importance. In addition thereto, the percentages of water, ash, crude fiber, and nitrogenous compounds or proteids will always be of interest since the proportions of these components will determine the manner in which a material must be worked. The fat percentage has little interest for a distiller, save perhaps as it may affect the feeding value of the distillery refuse; but it will be stated whenever possible, for the sake of completeness, in such analyses as are given.

It may be said in this connection that the five components just mentioned—water, ash, fiber, proteids, and fat—are always determined and reported as such, but, unfortunately, the fermentable substances—sugar, starch, etc.—are often not determined individually, but are combined and reported as "nitrogen-free extract," the percentage of which is obtained by subtracting the sum of the other components from 100. The value thus obtained for "extract" will of course include not only the sugar and starch, but also the unfermentable pentosans and the sum of the errors made in determining the percentages of the first five components. For these reasons the fermentable material actually present may be lower than the figures for nitrogen-free extract or carbohydrates would indicate, as from 5 to 10 per cent of this extract may be unfermentable. Whenever possible representative analyses have been used showing the amounts of starch, sugar, and unfermentable pentosans as individually determined and not as found by subtraction.

Saccharine Materials.

Agave.—Different species of this plant are used in the Southwest in the preparation of several varieties of distilled alcoholic liquors, and at least one distillery has been erected in the hope of utilizing them as a source of industrial alcohol. It is known that the juice of these plants contains large amounts of sugar at times, and there is every reason to believe that, with proper technical direction, they can be used profitably for industrial purposes.[1]

Fruits.—The average amounts of sugar contained in some of the common fruits are shown in the following tabulation:

Kind of fruit.	Average percentage of total sugars, calculated as dextrose.	Kind of fruit.	Average percentage of total sugars, calculated as dextrose.
Apple	12.2	Pear	10.0
Banana	13.8	Pineapple	11.7
Grape	15.0	Prickly pear	4.2
Orange	5.4	Tomato	2.0
Peach	7.6	Watermelon	2.5

It must not be supposed, however, that it is practicable to obtain all of the sugar in these fruits in a form suitable for fermentation. It would be necessary, in preparing any of them for distillation in a column still, to express the juice from the marc, since the latter, if allowed to enter the still, would impede its working, and obviously a certain proportion of the juice and of the sugar will remain in the marc.

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[1] A sample of one of these plants, sotol (*Dasylirion texanum*), was analyzed in the Bureau of Chemistry and found to yield 18 per cent of levulose.

Thus it is estimated that it would be impossible, in working with apples, to obtain more than 75 per cent of the total fermentable material, or about 9 per cent of the weight of apples delivered. On this basis, a ton of average apples should yield about 14 gallons of alcohol. Estimating the cost of gathering culls and windfalls, and of delivering them at the mill, to be $4 per ton, a figure based on actual experience, the raw-material expense for a gallon of alcohol will be at least 28 cents.

In the case of grapes, assuming that approximately 80 pounds of juice may be expressed from 100 pounds of Concords, and that this juice contains 18 per cent of total sugars, a ton of fruit should yield between 21 and 22 gallons of alcohol. If the expense of picking and hauling grapes to the distillery is placed at $6 or $7 a ton—a figure obtained from a grape-growing district in California—the cost of raw material for a gallon of alcohol will be 30 cents.

In the case of watermelon, if a 90 per cent extraction of juice containing 2.5 per cent of sugars is obtained, a ton of melons will yield about 3½ gallons of alcohol. If the cost of gathering and hauling the fruit is set at $2 per ton, the raw-material cost will be not less than 50 cents per gallon of alcohol.

In these three specific cases, it has been assumed that the fruit itself was valueless on the spot where grown, and that it could be delivered at the distillery for the mere cost of gathering and hauling. Even on that basis, it would be too costly to use as raw material in making industrial alcohol. The fact that fruit is extensively used in the manufacture of wines and brandies, has no bearing on the present discussion for the reason that the value of potable liquors bears but little relation to the amounts of alcohol which they contain, but is governed almost entirely by the qualities of their flavors and aromas.

Molasses.—Beet molasses, a refuse from the manufacture of beet sugar, is used on a very large scale abroad, and in several distilleries in this country, as a raw material for alcohol production. Usually, it contains about 50 per cent of sugar, and it generally needs only to be diluted and acidified to prepare it for fermentation. Sometimes a lot will not ferment readily, but generally it is worked without any difficulty. A ton should yield from 75 to 80 gallons of alcohol. At $15 per ton, the raw material for a gallon of alcohol will cost 19 or 20 cents.

Cane molasses contains usually about 25 per cent of water, 20 per cent of nonsaccharine solids, and 55 per cent of sugars. The following figures show the composition of two samples of typical distillery molasses of different origins, one being a Louisiana blackstrap and the other a Porto Rican molasses.

Analyses of two typical kinds of molasses.

Determination.	Louisiana.	Porto Rican.
	Per cent.	*Per cent.*
Water	23.5	24.3
Sucrose	26.6	35.8
Reducing sugars	29.1	18.3
Nonsugars	20.8	21.6
Total	100.0	100.0

Almost invariably, cane molasses needs only to be diluted and yeasted to enter into vigorous fermentation. It is common, however, for molasses distillers to add a certain amount of acid to the fermenting solutions to prevent bacteria from invading them and setting up false fermentations. In some cases sulphuric acid is used for this purpose, as in the beet molasses distilleries, but it is equally common, and probably wiser, to use sour distillery slop to produce the desired acidity. A ton of molasses, having the composition of the Louisiana sample given in the table, will have a volume of about 173 gallons and yield approximately 85 gallons of alcohol. At 3 cents per gallon, for which such molasses could be bought only a few years ago, the cost of the material for a gallon of alcohol would be little over 6 cents. The increasing utilization of molasses as a feeding stuff has advanced its price to from 6 to 10 cents, but at some plantations it is probably still cheap enough to retain its old position as a most advantageous raw material for the distiller.

Sorghum.—A large number of analyses made in the Bureau of Chemistry[1] indicates that the juice of saccharine sorghum has the following average composition:

	Per cent.
Water	81.4
Sucrose	12.7
Reducing sugars	1.1
Undetermined solid matters	4.8
Total	100.0

With a light horse-driven mill, about 60 per cent of the weight of the topped and cleaned cane can be obtained in the form of juice. With a heavy mill, such as is used in cane-sugar manufacture, an extraction of at least 75 per cent should be obtained. An extraction corresponding to 65 per cent of the weight of the cleaned stalks may, therefore, be considered a fair average. On this basis a yield of about 14 gallons of 180° alcohol per ton of cleaned stalks would be obtained. If the latter could be delivered at the distillery at a cost of $3 per ton, the material for a gallon of alcohol would represent a value of about 21 cents. A relatively slight improvement in the quality of the juice and in the extraction would lower the cost of material per unit of production very much. Thus, 1,000 pounds of the juice of the Colman sorghum, containing 14.42 per cent of sucrose and 1.10 per cent of reducing sugars, should yield 12¼ gallons of 180° alcohol. The yields of alcohol to be expected from a ton of cleaned Colman stalks, and the cost of material per gallon of spirit, are shown in the following tabulation for different degrees of juice extraction.

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[1] U. S. Dept. Agr., Division of Chemistry Bul. 34, pp. 23 et seq.

Yields of alcohol from sorghum stalks with varying degrees of juice extraction.

Proportion of juice extracted from stalks.	Yield of 180° alcohol per ton of cleaned stalks.	Cost of material per gallon.
Per cent.	*Gallons.*	*Cents.*
65	15.92	18.85
70	17.15	17.50
75	18.35	16.35

Since the gums and slimy bodies contained in sorghum juice do not interfere in the least with its fermentation, and the plant can be grown readily over a very wide range of territory, it is plain that the material deserves favorable consideration in connection with the manufacture of alcohol, and that it is likely to be utilized in the future in this way.

Sugar beets.—The following figures relative to the composition of the sugar beet may be considered as a representative analysis:[1]

	Per cent.
Water	81.51
Ash	.62
Protein	1.72
Fiber	1.35
Fat	.07
Carbohydrates	14.73
Total	100.00

The records of several experimental fields cultivated at the agricultural experiment stations in California, Colorado, Michigan, and Wisconsin show sugar percentages running from 13 to 16. Fourteen per cent will probably be a fair commercial average for the content of fermentable material in sugar beets as grown at present.

In France, where the beet has been used extensively as a source of alcohol, it has been found necessary to extract the juice for fermentation, using one of the extraction methods employed in the sugar factories. The pulp, while it offers no obstacle to fermentation, forms a jelly on heating which interferes seriously with distillation. Data obtained from the results of actual distillery yields show that for every 100 pounds of sugar contained in the beets entering the French distilleries, 7.1 gallons of absolute alcohol were produced, equivalent to 8 gallons at 180° proof, which is the minimum strength used in this country for denaturing purposes.

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[1] Twelfth Ann. Rept. Ind. Agr. Exper. Sta., 1899, p. 71.

With beets at $4.75 to $5 per ton, the price commonly paid by sugar factories in this country, and a sugar content of 14 per cent, the raw material needed to produce a gallon of 180° alcohol would represent a value of 22 cents. Under present conditions this probably would be a prohibitive price, but the time may come when beets will be used as a source of alcohol in the United States as they are in Europe.

Sugar cane.—Spencer gives the following figures as the average of about 40 cane-juice analyses made at the Magnolia Plantation, La.:

	Per cent.
Water	83. 6
Sucrose	14. 1
Reducing sugars	. 6
Undetermined solids	1. 7
Total	100. 0

On the presumption that 72 per cent of the total weight of the sugar cane can be obtained by two pressings, as juice of this composition, a ton of cane should yield 16.7 gallons of alcohol. If cane is worth from $3 to $3.25 at the factory, this would make the cost of the raw material for the alcohol about 19 cents per gallon.

Sugar-corn cannery wastes.—The stalks of the sugar corn contain quite large amounts of sugar, analyses made in the Bureau of Chemistry having disclosed its presence in proportions varying between 7 and 15 per cent. Investigations conducted at a corn cannery in Illinois, in 1906, showed that the waste stalks amounted to about 40 per cent of the total weight of corn brought to the factory, and that it was possible to produce from them from 6 to 10 per cent of alcohol, with a safe average of 8 per cent. On this basis about 11 gallons of alcohol should be recovered for every ton of corn delivered to the cannery. Unfortunately, the season during which these stalks are suitable for utilization in the manufacture of alcohol is very limited, and probably it would not pay to put up a distillery to handle them, unless other cheap materials were available for use during the rest of the year.

Starchy Materials.

Certain materials contain an essential part of their fermentable material in the form of starch, even though some of them, like artichokes and sweet potatoes, also contain notable amounts of sugar. They differ from the saccharine materials, in requiring to be "mashed" before they can be fermented. This operation is discussed in detail on page 25.

GRAINS.

Barley.—The average composition of ordinary six-row barley is approximately as follows:

	Per cent.
Water	8.7
Ash	3.0
Protein	11.9
Fiber	5.8
Fat	2.0
Starch	58.9
Pentosans	9.6
Total	99.9

On account of its expensiveness, barley is never used by itself as a source of industrial alcohol. It is, however, used in large quantities in making malt, which operation is described on page 24. The composition of a typical malt is as follows:

	Per cent.
Water	5.9
Ash	2.7
Protein	11.5
Fiber	6.0
Fat	2.1
Starch	48.4
Sugars	12.2
Pentosans	10.6
Total	99.4

It is customary to use about 8 pounds of malt to saccharify 100 pounds of raw grain. Two pounds will be sufficient for mashing 100 pounds of potatoes.

Maize (Indian corn).—The following figures represent the average of a large number of analyses taken mostly from the work of the Illinois experiment station.

	Per cent.
Water	10.0
Ash	1.5
Protein	10.4
Fiber	1.9
Fat	5.2
Pentosans	5.0
Sugars	2.0
Starch	64.0
Total	100.0

A lot of distiller's corn (yellow dent) used in the experimental distillery of this department, and analyzed in the Bureau of Chemistry, was found to contain 72.8 per cent of nitrogen-free extract, including 57.9 per cent of starch and 2.3 per cent of sugars, in addition to pentosans, gums, etc.

The method of working this and other grains is described on pages 23 to 27. One ton of grain, made up of 1,850 pounds of maize and 150 pounds of malt of the compositions given above, should yield 100 gallons of 180° alcohol. At 50 cents a bushel for corn and 65 cents a bushel for the barley necessary to make the malt, the ton of grain will cost about $19, and the cost of raw grain, per gallon of alcohol, will be 19 cents.

Maize is, and always has been, the chief source of industrial alcohol in this country. The ease with which it is raised, its ability to stand transportation and storage, and its low price in past years, have combined to give it a preeminence as a distillers' raw material, which it undoubtedly will retain for many years.

Oats.—This grain, which contains about 50 per cent of fermentable material and which might with care be made to yield about 70 gallons of alcohol per ton, is unsuited to distillery use on account of its greater value as a feeding stuff, and the glutinous nature of the mixture which is formed when it is treated with hot water.

Rye.—A lot of this grain used in the experimental distillery had the following composition:

	Per cent.
Water	9.4
Ash	2.1
Protein	10.7
Fiber	1.9
Fat	1.9
Starch	53.7
Sugars	5.6
Pentosans, gums, etc	14.7
Total	100.0

This material is used very largely in distilleries which produce compressed yeast or rye whisky, and it sometimes is employed in small amounts in the yeast mashes of alcohol distilleries, but it is not suitable for use as the chief ingredient of the mash in an alcohol distillery on account of its expensiveness and though containing about 60 per cent of fermentable matters it rarely yields over 85 gallons of alcohol to the ton.

Sorghum seed.—This grain, regarding which many inquiries are made, has the following average composition, closely resembling that of maize:

Comparison of sorghum seed and Kafir corn.

Determination.	Sorghum seed.	Kafir corn.	Determination.	Sorghum seed.	Kafir corn.
	Per cent.	*Per cent.*		*Per cent.*	*Per cent.*
Water	8.3	12.5	Pentosans	4.3	
Ash	1.8	1.3	Sugars	1.5	
Protein	13.3	10.9	Nitrogen-free extract	66.3	70.5
Fiber	1.5	1.9			
Fat	3.0	2.9	Total	100.0	100.0

Undoubtedly sorghum seed could be worked in the distillery as corn is and probably would require less cooking and give fully as good a yield, though its use for this purpose has never been tested as far as the writer knows.

Wheat.—What has been said regarding the yield of alcohol to be obtained from rye applies in a general way to wheat also. Although wheat contains nearly 65 per cent of starch and sugars, it is too expensive to be used for alcohol production unless frozen or for other reason unavailable for food purposes.

	Per cent.
Water	10.5
Ash	1.9
Protein	11.5
Fat	2.0
Fiber	2.3
Sugars	2.8
Pentosans	7.0
Starch, etc	62.0

ROOTS.

Artichoke.—The tuber of the Jerusalem artichoke has the following average composition:[1]

	Per cent.
Water	79.0
Ash	1.0
Protein	1.3
Fiber	.8
Fat	.2
Pentosans	1.2
Nitrogen-free extract	16.5
Total	100.0

It is seen that artichokes contain from 16 to 18 per cent of fermentable matter in the form of levulose and inulin, and as the latter may be converted into the former without the use of malt, by merely boiling under pressure, it can be worked very cheaply. When 17 per cent of fermentable substance is present, a ton should yield about 25 gallons of alcohol; and as it can be raised and delivered for about $5 per ton the raw material for a gallon would cost about 20 cents. The tuber has remarkably good keeping qualities and deserves far more attention than it has yet received as a distillers' material.

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[1] Behrend, J. Landw., 1904, 52: 127.

Cassava.—The root of the sweet cassava has the following average composition:

	Per cent.
Water	65.0
Ash	.7
Protein	.9
Fiber	1.7
Fat	.3
Starch	25.4
Nitrogen-free extract	6.0
Total	100.0

It is fair to assume that about 80 per cent of the dry matter of the root, or about 28 per cent of the weight of the root itself, is fermentable. On this assumption a ton of roots should produce about 42 gallons of alcohol. At $5 per ton, which would be a fair price with modern methods of cultivation, the raw material would cost about 12 or 13 cents per gallon of alcohol. In so far as is known, cassava has never been used as a source of alcohol. That technical difficulties might arise in handling it is very possible, but the analytical data and cost afford every reason for testing the value as a source of alcohol.

Potatoes.—Following is the average composition of Maine potatoes, as determined a few years ago in the Bureau of Chemistry:

	Per cent.
Water	77.0
Ash	.9
Protein	2.2
Fiber	.7
Fat	.1
Starch	18.3
Sugars, etc., by difference	.8
Total	100.0

Samples analyzed more recently in connection with the work of the experimental distillery were found to contain about 15 per cent of starch and 0.4 per cent of sugars. Liquid wastes from starch factories in Maine were also examined, but did not contain sufficient fermentable material to be of value for alcohol production.

The method of working potatoes is indicated on page 25 and is discussed at length in Farmers' Bulletin 410. For every per cent of starch contained in potatoes they should yield about 1.6 gallons of alcohol per ton. If the tubers contain 16 per cent of starch, a ton should yield over 25 gallons of alcohol; and if they can be delivered at the distillery for $5 per ton, a fair price for culls in potato-growing regions, the raw material for a gallon of alcohol will cost about 20 cents.

In Germany the potato is almost the only material used as a source of industrial alcohol, not only because it offers a cheap raw material, but because it is highly advantageous from an agricultural point of view. It undoubtedly will be similarly utilized in this country in the future.

Sweet potatoes.—The following average data are based on work done at the South Carolina station[1] and may be considered as representing sweet potatoes of good quality:

	Per cent.
Water	66.0
Ash	1.0
Protein	1.5
Fiber	1.3
Fat	.5
Sugars	5.5
Starch	21.8
Undetermined material	2.4
Total	100.0

These roots are seen to contain about 27 per cent of fermentable substances, of which approximately one-fifth is sugars. In storage there is a decrease in the starch percentage and a corresponding increase in that of sugar.

Preliminary experiments conducted at the Bureau of Chemistry indicate that the sweet potato can be mashed in about the same way as the common potato. Undoubtedly there will be some slight destruction of sugar on heating under pressure, but it ought not be such as to cause a serious loss. It does not appear that the somewhat fibrous character of the root interferes with steaming it in an apparatus built for potatoes.

A ton of sweet potatoes, containing about 27 per cent of fermentable substances and costing $8, should yield approximately 38 gallons of alcohol at a cost of about 21 cents a gallon for raw material.

MANUFACTURE OF ALCOHOL.

HISTORICAL NOTE.

Although there are processes by which alcohol may be made synthetically in the laboratory, they are too complicated and expensive to have any practical manufacturing value. Therefore the method which has been used for many centuries, namely, the distillation of fermented-sugar solutions, is still employed in alcohol production. This manufacturing process is very ancient, having been used probably as early as 800 B. C. It seems for many centuries to have been employed only in preparing spirituous beverages of somewhat higher alcoholic strength than could be obtained by fermentation alone. The first stills were very crude and simple in design, and were incapable of producing distillates of great strength from the wine which invariably was used as the material for distillation. It was indeed found by the early chemists that if the first weak distillate were subjected to a second and third distillation its alcoholic strength could be raised (though at the expense of a material diminution in its volume) to such an extent that it would burn, but the expensiveness of the product thus obtained was too great to allow its use for any industrial purposes.

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[1] South Carolina Bul. 136, 1908, p. 11.

At present wine and other fermented fruit juices are distilled only for the production of potable spirits; and industrial alcohol is made altogether by the distillation of fermented saccharine solutions which are prepared either directly from raw materials containing sugar, such as molasses, or from starchy materials like potatoes or the cereal grains, after a preliminary treatment which converts their starch into sugar.

THEORY OF ALCOHOLIC FERMENTATION.

The process of alcoholic fermentation is established whenever yeast is allowed to act on sugar solutions of moderate strength at temperatures between 50° and 90° F. Theoretically the process consists of a simple splitting up of sugar into alcohol and carbonic acid gas, any given amount of sugar yielding proportionate and perfectly definite amounts of these two products of its decomposition. This is illustrated in the following example:

The chemical composition of dextrose, which is the form of sugar occurring in most ripe fruits, is represented by the formula $C_6H_{12}O_6$, which signifies that one molecule or unit of the compound substance dextrose is made up of six atoms or units of the element carbon, twelve of the element hydrogen, and six of the element oxygen. When fermentation takes place, the molecule of dextrose breaks up substantially as is indicated by the following equation:

$$C_6H_{12}O_6 = 2\ C_2H_5OH + 2\ CO_2.$$

This signifies that after fermentation is over the dextrose will have disappeared and in its place will be found an amount of alcohol containing all the hydrogen, two-thirds of the carbon, and one-third of the oxygen of the sugar, and an amount of carbon dioxid containing one-third of its carbon and two-thirds of its oxygen. Theoretically the total weights of the alcohol and carbon dioxid which are produced in the fermentation should equal exactly the weight of dextrose which is decomposed, and 100 pounds of the sugar should yield 51.11 pounds of alcohol and 48.89 pounds of carbon dioxid.

In practice, however, the decomposition is never complete, nor is it ever so simple as is indicated by the foregoing equation. Only in carefully conducted laboratory work is it ever possible to ferment any sugar completely; and even then, as a result of life processes of the yeast which are not yet understood by chemists or biologists, small and varying proportions of the sugar escape transformation into alcohol, and are converted instead into other substances. According to the investigations of Pasteur, 100 pounds of dextrose, instead of yielding the theoretical weights of alcohol and carbonic acid indicated by the equation, will produce in laboratory practice the following amounts of fermentation products:

	Pounds.
Alcohol	48. 55
Carbon dioxid	46. 74
Glycerin	3. 23
Organic acids	. 62
Miscellaneous	1. 23
Total	100. 37

The fact that the total weight of the fermentation products exceeds slightly the weight of sugar fermented is explained on the ground that the formation of certain of the by-products is accompanied by the absorption and fixation of slight amounts of water.

In manufacturing work, such completeness of fermentation may be taken as an ideal toward which one is to strive. According to the skill of the distiller, the character of his mechanical equipment, and the quality of his water, yeast, and fermentable materials, his yields of alcohol may approximate those indicated or may, on the other hand, fall far below it.

NATURE OF YEAST.

Yeast, the exciting agent of the alcoholic fermentation, is familiar to the general public chiefly in the form of the small square cakes which are sold at groceries, and to workers in breweries and distilleries as a more or less frothy paste. Whatever its outward form and appearance may be, it always is made up of innumerable microscopic plants which are globular or ovoid in form, approximately 1/4000 inch in diameter, and fairly colorless and transparent as seen under the microscope.

Yeast withstands prolonged exposure to cold without serious injury, but is weakened rapidly when kept at high temperatures, and is killed quickly when heated to about 110° F. It ordinarily reproduces itself by a process of budding, and grows at the expense of various nutrient materials, such as lime, potash, phosphoric acid, and nitrogenous compounds, which it absorbs from the solutions in which it is placed. The vigor of a fermentation seems to depend largely upon the phenomenon of yeast growth. Good fermentation can not be established without abundant and suitable nutrients for the yeast and its vigorous development.

The selection of a suitable yeast for any purpose and its preparation and maintenance in a pure and vigorous condition are arts which demand thorough training and experience. They can not be learned from books alone and call for no small amount of manipulative skill.

PREPARATION OF SACCHARINE SOLUTIONS FOR FERMENTATION.

Certain saccharine materials, such as the juices of most fruits and of the sugar cane, are in their natural condition so susceptible to fermentation that they can not be preserved unaltered unless they are sterilized in sealed bottles or some antiseptic or preservative material, such as salicylic acid, is added. Other sugar-containing materials, such as molasses, do not ferment readily until they have been subjected to certain preliminary treatments. Thus, both cane-molasses and beet-molasses must be diluted with water before they can be fermented; and since they often are deficient in the nitrogen compounds which are essential to yeast production it sometimes is found necessary to add nitrogen to their solutions in the form of ammonium sulphate or some equivalent material. Furthermore beet-molasses is usually alkaline, and as yeast will not work in alkaline solutions it is necessary to acidify beet-molasses before adding yeast to it. Diluted sulphuric acid is commonly used for this purpose. The amount of water or of chemicals which must be added to a given quantity of molasses to fit it for fermentation will depend upon the composition of the latter. Experience has shown that with ordinary cane-molasses it is desirable to use about six volumes of water for one of molasses. In this way a solution is obtained which contains about 12 per cent of sugar and is capable of producing approximately 6 per cent of alcohol. This proportion of sugar has been found, in general, to give the best results with regard to the rate, completeness, and economy of fermentation.

PREPARATION OF FERMENTABLE SOLUTIONS FROM STARCHY RAW MATERIALS.

While the saccharine raw materials of the fermentation industries can be prepared for use by the relatively simple processes of solution or juice expression, such materials as potatoes and grain, which contain little sugar and much starch, must be subjected to special treatment in order to convert the insoluble and unfermentable starch into sugar. The series of operations by which this starch conversion is accomplished is called "mashing," and consists of a preliminary scalding or cooking process, the purpose of which is to liquefy the starch, and of the saccharification proper, in which the soluble starch is converted into dextrin and sugar. The agency by which the latter conversion is accomplished is the specific action (in the presence of moisture, and at a suitable temperature) of certain substances called enzyms, which usually are developed for this particular purpose in a portion of the grain used for mashing, by a process called malting.

Malting.—When the seeds of any cereal are moistened and allowed to sprout, changes in their chemical composition take place which are fully as striking as the accompanying changes in the appearance of the grains. Most important of these is the formation of bodies which have the power, when dissolved in water and allowed to act at a suitable degree of warmth, of corroding the insoluble starch granules of the grain, of rendering them soluble, and of converting the starch ultimately into a fermentable sugar called maltose. Grain which has been treated so as to develop these bodies is called malt.

These enzyms, or active bodies of the malt, are usually grouped under the name diastase, and they appear during the sprouting of all starchy seeds. Their formation has been utilized technically in the case of several of the cereals, such as wheat, rye, oats, maize, and barley. Rye and barley produce diastase more abundantly than the other grains, and are employed in large quantities in the malting industry. Of the two, barley is most used on account of the protection which is afforded by its husk to the tender kernel of the grain during the rough handling incidental to the malting process.

In making malt the barley is cleaned thoroughly by screening and washing, and is then steeped in water until the grains have absorbed enough water to soften them thoroughly and prepare them for germination. The excess of water is then drained off, and the wet grain is spread evenly on a smooth and scrupulously clean floor in a well-ventilated room which can be kept at a temperature of about 55° to 60° F. The grain is turned frequently, with wooden shovels, to keep it uniformly moist and to prevent its overheating, and as sprouting progresses it is gradually spread over a greater floor area so that a pile which originally was from 12 to 18 inches deep may finally have a depth of only 3 or 4 inches.

Malt which is intended for shipment is usually grown for about a week at a temperature not exceeding 68° F., after which it is dried slowly in kilns that are gradually raised from 95° to 125°, until only 2 or 3 per cent of moisture remains. Malt which is made in the distillery where it is to be used may be grown at about 55° for three or four weeks, and should then be used without having been dried. Green malt, thus prepared, has a much higher diastatic power[1] than the dried malt of commerce.

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[1] The power of converting starch into sugar.

would be impossible, however, to make any quantity of a 90 per cent distillate with such an apparatus except by incurring an expense for fuel and labor which would far exceed the highest possible industrial value of the product.

Fortunately it is possible so to construct a still that the requisite number of redistillations take place simultaneously in a single apparatus with little more outlay for fuel and labor than would be required to subject the same volume of beer to a single distillation in the pot still shown in figure 3. Such a complex apparatus, known as a column still, costs much more to build than does a simple still of the same beer capacity, but its almost automatic action and the saving which it affords with regard to labor, fuel, and water make it a necessary investment for any distillery which is designed to produce industrial alcohol.

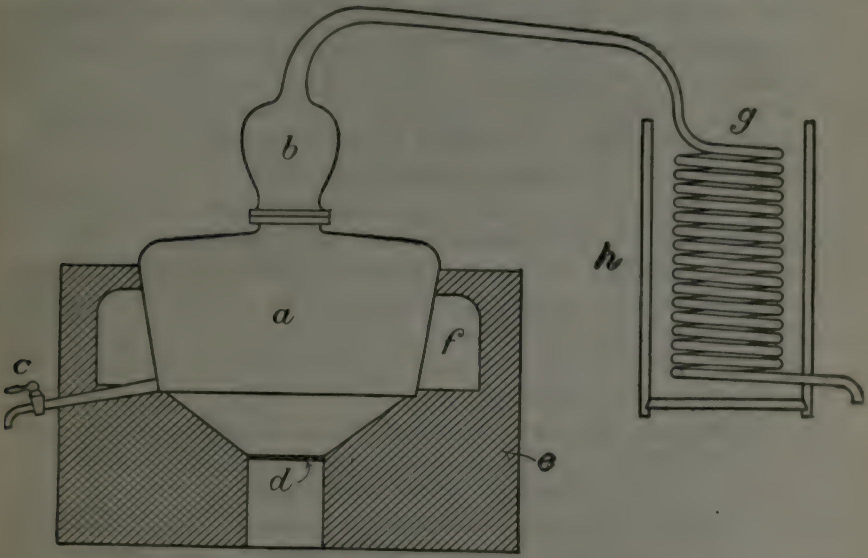

FIG. 3.—Fire-pot still.

a, Kettle of still; *b*, head of still; *c*, draw-off cock; *d*, grate; *e*, masonry support; *f*, flue; *g*, condensing worm; *h*, worm tub.

Detailed instructions for the operation of a column still and an illustration showing its various parts are given in Farmers' Bulletin 410, page 17, and will not be here repeated. Although the details may seem somewhat complicated, the actual management of a continuous still is in fact quite simple. When its operation is once well under way a condition of equilibrium is established in the working of its various parts, and as long as the supplies of water, steam, and beer are kept uniform it is possible to maintain a steady flow of distillate of practically constant proof for hours at a time, with comparatively little attention from the distiller.

GOVERNMENTAL CONTROL OF A SMALL DENATURED-ALCOHOL DISTILLERY.

Certain important features of the regulations of the Bureau of Internal Revenue are of special interest to those to whom the subject is new.

First of all, the mere possession of any still or distilling apparatus set up, even though the same is not employed in distilling alcohol, subjects its possessor or custodian to heavy penalties unless he has registered it in writing with the collector of internal revenue for the district in which it is located. The distillation of alcohol is forbidden by law, except when conducted in accordance with the regulations issued by the Bureau of Internal Revenue and under the supervision of a designated officer, no matter how much the alcohol may be mixed or diluted with other substances. These facts are emphasized because they directly contradict the statements sometimes made that apparatus and processes can be furnished by which denatured alcohol can be made without Government supervision.

Other points worthy of mention in this connection are as follows:

Distilleries are to be constructed and their machinery is to be arranged in compliance with the regulations. (Secs. 14–24, pp. 45–50.[1])

The distiller must own or control the land on which the distillery is erected. In case that he does not own it or that it is mortgaged he must file the written consent of the owner or mortgagor to its use for distillery purposes. (Sec. 4, p. 41.)

The distiller must give written notice of his intention to engage or continue in the distilling business, stating what kinds of material he intends to use. (Secs. 5 and 13, pp. 41–42 and 45.)

The distillery, when ready for operation, must be "surveyed" by a designated Government official. (Secs. 25 and 6–12, pp. 50 and 42–45.)

Before beginning operations, the distiller must file a bond, signed by himself and two sufficient sureties, for an amount not less than the tax on all the spirit that the distillery could produce in a month. (Secs. 26–27, pp. 50–52.)

The survey having been made and the bond filed, the distiller must give notice of the day on which he will begin operations. (Sec. 29, p. 52.)

Records must be kept by the distiller, for inspection by the revenue officers, of the amounts and kinds of material received and used and of the amount of alcohol produced. (Secs. 34–37, pp. 54–57.)

No kind of spirit save alcohol for denaturing purposes can be produced at an industrial distillery. (Sec. 38, p. 57.)

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[1] U. S. Internal Revenue Reg. No. 30, rev.

When a revenue officer is assigned to a distillery, it must be operated regularly on every day except Sundays. (Sec. 39, p. 57).

Methods are prescribed by which denaturants may be obtained and used. (Secs. 41–44 and 49, pp. 58, 59, and 61.)

FACTORS INFLUENCING THE COST OF MANUFACTURING ALCOHOL.

While cheap and abundant raw material is indeed essential to the profitable production of denatured alcohol, there are other factors, no less important, which enter into the cost of manufacture. Some of these are as follows:

Interest and depreciation.—A small distillery can hardly be built and equipped for less than $12,000. Interest on the investment may therefore be set at about $700 a year; and a like amount ought to be allowed for keeping the plant in good working order. The capacity of such a plant can be doubled without any very great increase in cost; and if the capacity be halved, the reduction in cost will be relatively small.

Labor.—At least three and probably four men will be needed to run any distillery, however limited its capacity. Increase of the production up to 400 or 500 proof gallons daily would probably not call for additional labor. Five men undoubtedly could handle a plant producing 1,000 gallons daily.

Water.—A large amount of pure cold water is needed for the operation of a distillery. This fact is generally unknown, save to those who are engaged in the distilling business. A plant capable of producing 100 proof gallons, or 55 gallons of 180° alcohol, in a working day of ten hours, will need a supply of water amounting to not less than 3,000 gallons in that length of time, or five gallons per minute, and may demand considerably more.

Fuel.—Little definite information is available regarding the amount of fuel necessary for the operation of a small alcohol distillery. This dearth of accurate knowledge is regrettable, for the coal bill is a prominent item in the distillery's expense account. Such data as are at hand indicate that the coal consumption—per gallon of 180° alcohol produced—may vary from 11 pounds under the most favorable conditions to 38 pounds in a poorly equipped and poorly managed plant. As 11 pounds of coal as a distillery fuel yield almost 159,000 heat units and a gallon of alcohol gives about 75,000, it is apparent that the use of alcohol so produced for heating would involve a great waste and be altogether unprofitable. Furthermore, the coal consumption of a small distillery will be proportionally greater than that of a large one, since many economies which are possible in a large plant are quite impracticable in a small one.

CONCLUSIONS.

It is apparent that the business of distilling alcohol is one which calls for a considerable investment and no small degree of technical skill. It can not be conducted advantageously, from a commercial point of view, in very small plants on account of the proportionately high cost of the plant and of labor; and many of the so-called "wastes" which have been suggested as fermentable raw materials are so poor in fermentable substance or so expensive to handle that their availability is thereby impaired. It seems that the business, to be productive of satisfactory returns, must be conducted on a fairly large scale, and that the best success is likely to be attained with raw materials of the general types already in use, namely, maize, potatoes, and molasses. The industry is not suited to every locality, and it is most likely to be successful if carried on systematically on a very large farm, or if supported by the joint interests of a fairly large community. The alluring statements sometimes made regarding large financial returns to be obtained by making industrial alcohol with waste raw material, unskilled labor, and a "cheap" distilling outfit are misleading and can only result in loss if followed.

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1329 Issued February 6, 1911

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 430.

Experiment Station Work,

LXI.

Compiled from the Publications of the Agricultural Experiment Stations.

UNUSUAL *v.* STANDARD FERTILIZERS.
SYMPTOMS OF DISEASE IN PLANTS.
PREMATURE DROPPING OF FIGS.
CONDIMENTAL FEEDS.
FEEDING THE DAIRY CALF.
DEFECTS IN COTTAGE CHEESE.
THE IOWA SILO.

NOVEMBER, 1910.

PREPARED IN THE OFFICE OF EXPERIMENT STATIONS.
A. C. TRUE, Director.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

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[a] Director.

[b] Special agent in charge.

EXPERIMENT STATION WORK.

Edited by W. H. BEAL and the Staff of the Experiment Station Record.

Experiment Station Work is a subseries of brief popular bulletins compiled from the published reports of the agricultural experiment stations and kindred institutions in this and other countries. The chief object of these publications is to disseminate throughout the country information regarding experiments at the different experiment stations, and thus to acquaint farmers in a general way with the progress of agricultural investigation on its practical side. The results herein reported should for the most part be regarded as tentative and suggestive rather than conclusive. Further experiments may modify them, and experience alone can show how far they will be useful in actual practice. The work of the stations must not be depended upon to produce "rules for farming." How to apply the results of experiments to his own conditions will ever remain the problem of the individual farmer.—A. C. TRUE, Director, Office of Experiment Stations.

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EXPERIMENT STATION WORK.[a]

UNUSUAL VERSUS STANDARD FERTILIZERS.[b]

John S. Burd, of the California Experiment Station, calls attention to attempts that are made from time to time by means of articles in newspapers and periodicals and by advertising literature to exploit various naturally occurring rocks and mineral deposits as fertilizers, and states that such of these propositions as he has been able to investigate are totally without merit.

It should be borne in mind that few materials have any fertilizing value until refined or otherwise treated with a view especially to making their constituents readily available to plants. "The idea has frequently been advanced that certain common rocks, notably those containing potash feldspar, should be of value as fertilizer because of their content of potash." Although many of these materials are relatively rich in potash it is combined in such insoluble forms that "it is difficult to see how applications of such materials would result in any immediate or important crop increase."

The well known fact that lava rocks have frequently broken up into fertile soils within a very limited period is used as an argument to prove that lavas should make a good fertilizer. This, however, does not follow. A mineral fertilizer to be worth the cost of application should contain relatively large amounts of one or more of the so-called "plant foods" in a comparatively easily soluble condition. To furnish an amount of actual potash equivalent to that in an ordinary application of sulphate of potash would require a relatively enormous quantity of ground lava of average composition. In addition the condition in which potash, the essential constituent, is combined with the other rock constituents is such as to justify little hope of its being utilized by plants within a reasonable period of time. Potash insoluble in water, as it occurs in such materials, has no standing among reputable agriculturists.

In brief, if these unusual materials have any agricultural value at all it is likely to be only under exceptional conditions, and therefore the average farmer will find it safest to depend upon the standard, well-known sources of supply for his fertilizing materials. These are subject to state inspection, which affords a guaranty of composition and protection to the purchaser.

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[a] A progress record of experimental inquiries, published without assumption of responsibility by the Department for the correctness of the facts and conclusions reported by the stations.

[b] Compiled from California Sta. Circ. 56.

SYMPTOMS OF DISEASE IN PLANTS.[a]

It is highly important that farmers and horticulturists should be able to recognize plant diseases. Many fail to do this because they do not know the general symptoms that indicate the attacks of insect or fungus enemies.

Plant diseases may be divided into three groups: (1) Nutrition disturbances due to unfavorable conditions in the environment of the plant or inherent in the plant itself; (2) troubles due to parasitic plants, usually either bacteria or fungi, but sometimes to flowering plants, which deform, stunt, or kill the plant; and (3) insect pests, which are in many cases very evident but often not easily detected.

The first step of importance to the farmer is to be able to determine the presence of disease and to endeavor to find out its cause, nature, and probable outcome, and the treatment which should be employed. The principal symptoms of disease in plants are the following: (1) Discoloration, or change of color from (*a*) normal green to a yellow or white pallor; (*b*) colored spots or areas, as white or gray on leaves or stems, such as mildews or white rusts, many leaf spots of yellow, red, orange, brown, black, or variegated colors, red or orange rusts, black rusts, tar spots, and the like; (2) shot-hole perforation of leaves; (3) wilting, such as damping off or wilt; (4) necrosis, such as death of parts of plants, leaves, twigs, stems, or flowers; (5) reduction in size, such as dwarfing or atrophy; (6) increase in size, such as hypertrophy; (7) replacement of organs by new structures; (8) mummification; (9) change of position; (10) destruction of organs; (11) excrescences and malformations, such as pustules, tumors, corky outgrowths or crown galls, cankers from malformations in the bark generally resulting in an open wound, punks, or conches and other fruits of fleshy fungi, witches' brooms, rosettes, and hairy root; (12) exudations, such as slime flux, gummosis (especially for stone fruits), and resinosis (especially for coniferous trees); and (13) rotting, such as dry and soft rots, root rots of alfalfa, cotton, beets, or cherries (generally of fleshy or woody roots), stem or trunk rot, such as dry rot of trees and of modified stems like rhizomes, bulbs, or tubers, and bud and fruit rot of various fleshy fruits.

Soils decidedly alkaline, lacking in proper drainage, or deficient in iron may produce a yellowing of the foliage, while discoloration of restricted areas on the leaves is usually due to the attacks of some insect or plant parasite, presumably the latter.

In general, any marked variation in color or shape from the normal type is a sure indication of disease which in many cases may be controlled and the crop saved if taken in hand promptly.

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[a] Compiled from Vermont Sta. Buls. 142 and 147; Bul. Univ. Texas, Sci. Ser. No. 14.

THE PREMATURE DROPPING OF FIGS IN THE SOUTH.[a]

In a recent bulletin on fig culture F. C. Reimer of the North Carolina Station calls attention to the wholesale premature dropping of the crop which occurs annually with many fig trees in that State and in other States as well.

> There are many fig trees in this State which would produce several bushels of fruit every season if it could grow to maturity; but when about two-thirds grown the fruit turns yellowish, begins to shrivel, becomes dry and tough, and then drops. With the first crop it all drops within a few days; while with the second the dropping extends over a long period, each fruit falling as soon as it reaches a certain size or stage of maturity.

This trouble has been attributed to various causes such as adverse weather conditions, too rapid growth, poor soil, and lack of proper fertilization. After examining specimens of fruit received from various sections of the State, however, together with many others personally collected, Professor Reimer finds that wherever the dropping is at all serious the trouble is due to the kind of fig grown. Fully 95 per cent of the figs examined were true Smyrna seedlings and of no value for culture in the South since the flowers of these seedlings must be fertilized by the flowers of the wild fig or caprifig; otherwise the fruit will shrivel and drop off before maturing. Thus far neither the caprifig nor the fig wasp *Blastophaga grossorum*, which is reared in the caprifig and carries the pollen to the flowers of the Smyrna fig, has been successfully domesticated in this country, except in the warmer sections of California where the Smyrna fig industry is being developed to a considerable extent.[b]

The caprifig rarely produces edible fruit, hence whether the seedlings partake of the nature of the Smyrna fig or of the caprifig they are of no value in the South and, as Professor Reimer recommends, they should be destroyed and replaced with varieties of known value, such as the Brown Turkey or the Celestial, which varieties have thus far proved to be the best in the latitude of North Carolina. Farther south many other excellent varieties can be grown.

A previous bulletin of this series contains considerable detailed information relative to fig growing in the South.[c]

CONDIMENTAL FEEDS.[d]

In a previous bulletin of this series[e] attention was called to experiment station investigations which showed that the value of condimental feeds and condition powders for stock usually found on the market has been exaggerated. A number of feeding experiments at the state stations since that article was published have furnished additional evidence that these feeds do not produce the wonderful results claimed for them, but when used to any large extent greatly increase the cost of beef, pork, and milk production because of the exorbitant prices at which many of them are sold. Some of these feeds sell for $200 to $300 per ton, but contain material actually worth only $20 to $45 per ton.

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[a] Compiled from North Carolina Sta. Bul. 208.

[b] There exists, however, no doubt that the caprifig and its attendant wasp (*Blastophaga grossorum*) can be successfully propagated in our Southern States.

[c] U. S. Dept. Agr., Farmers' Bul. 342, pp. 239–246.

[d] Compiled from Indiana Sta. Bul. 93; Iowa Sta. Bul. 87; Maine Sta. Rpt. 1896, p. 52; Massachusetts Sta. Bul. 86; Vermont Sta. Bul. 104.

[e] U. S. Dept. Agr., Farmers' Bul. 233, p. 21.

If farmers wish to give condiments or tonics to their stock, it would be much cheaper to buy the ingredients commonly used and do their own mixing. The following formula for a condimental feed, recommended by the Vermont and Maine stations, can be prepared for about 20 cents per pound, and is much cheaper and better than many of those commonly sold: Ground gentian 1 pound, ground ginger ¼ pound, powdered saltpeter ¼ pound, powdered iron sulphate ¼ pound; mix and give 1 tablespoonful in the feed once daily for ten days; omit for three days, and feed as above for ten days more.

The Iowa Experiment Station suggests the following: Fenugreek 8 pounds, ginger 8 pounds, powdered gentian 8 pounds, powdered sulphur 8 pounds, potassium nitrate 8 pounds, resin 8 pounds, cayenne pepper 4 pounds, flax meal 44 pounds, powdered charcoal 20 pounds, common salt 20 pounds, wheat bran 100 pounds. This mixture costs less than $5 per 100 pounds and very nearly approximates the composition of the average condimental feed. However, the farmer must realize that—

> A tablespoonful of such a mixture fed night and morning would not put his stock on the market in thirty days less time, neither would it double the flow of the milk of his dairy herd, nor would it prevent cholera in hogs, abortion in cattle, roup in chickens, or glanders in horses. It is yet to be proved that any stock food or tonic will do this. The feeding of domestic animals is and always will be a matter of applied common sense and intelligence. But such a stock food would have the merit of being extremely inexpensive, besides having as much merit in other ways as any of its class.

FEEDING THE DAIRY CALF.[a]

An article in a previous bulletin of this series[b] dealt particularly with substitutes for whole milk in calf feeding. It is the purpose of this article to present a brief review of the whole subject by D. H. Otis, of the Wisconsin Experiment Station. In the first place Professor Otis calls attention to the herdsman's responsibility in feeding and caring for the dairy calf. If the dams have been properly nourished the value of the calves at birth depends largely, if not entirely, upon the intelligence and skill exercised by the owner in their breeding.

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[a] Compiled from Wisconsin Sta. Bul. 192.

[b] U. S. Dept. Agr., Farmers' Bul. 381, p. 14.

The future possibilities of the newborn calf, however, rest on the thought and skill that the owner puts into its feed, care, and management. Mistakes at this period of the calf's life are probably of lifelong influence, while a mistake in feeding and caring for a mature animal may be only temporary in its effects. Calf feeding requires skill and good common sense, as there are no hard and fast rules that can be laid down.

Young calves need whole milk for the first few days. The calf should always have the first or colostrum milk of the cow and be allowed to nurse the cow until the eighth or ninth milking, when the milk is suitable for human food. Feed often with small amounts to avoid overfeeding. Teach the calf to drink and feed whole milk for at least three weeks, changing to a skim milk diet gradually.

By good feed and care, or the lack of it, it is easy to make a variation of $1 to $5 or even $10 per head in the value of the calf the first year.

Skim milk is a cheap feed for calves but should be fed carefully in limited quantities and only while it is warm and sweet. Skim milk may form the principal diet of the calf for eight months or a year. Factory skim milk should always be pasteurized to avoid the spread of tuberculosis. The best skim milk is that which is fresh from the separator and still warm. Experiments show that it is only one-fourth as expensive to raise a calf on skim milk as whole milk. Two pounds grain with the proper amount of skim milk equals one pound of butter fat. Buttermilk or whey may profitably be fed to calves.

Milk that is too rich may cause serious trouble from scours, and in feeding such milk care should be exercised to give limited amounts at the proper temperature. The feeding of whole milk should be continued for about three or four weeks, when the number of meals may be reduced to two per day. From one-half to a pint of skim milk may now be substituted for an equal quantity of whole milk. The amount of skim milk may be gradually increased and the amount of whole milk correspondingly decreased until, at the end of a week or ten days, the calf is getting all skim milk. Feed the milk sweet and at blood temperature.

Not over 10 to 12 pounds of milk daily should be fed until the calf is 5 to 7 weeks old. Later the amount may be increased to 14 or 16 pounds and at three months may, though not always, go to about 20 pounds. The amount fed, however, must be carefully regulated by the ability of the calf to handle it without scouring.

The grain for calves should be fed first while the calf is quite small with a little bran to aid the calf in learning to eat. High-priced concentrates are unnecessary and give no better results than corn meal, oats and bran, ground barley, etc., when fed in proper combinations. At four to six weeks a calf has good teeth and can grind his own feed. A variety of feeds is advantageous and best results will usually be secured from mixtures.

The roughage for calves should first be fed at two or three weeks of age when the calf begins to eat grain. Good clean hay, either timothy, blue grass, clover, or alfalfa may be used. Corn silage is an excellent calf feed when fed in moderate amounts. Good pasture is an essential after four to six months of age, and if the calf is turned out for only a few hours each day at first scours will be avoided.

Whey has the casein as well as the butter fat removed and hence is a much less valuable feed than skim milk; a good grain ration must be carefully selected as a supplementary feed. The calf to be fed on whey should receive whole milk for the first week or two; it can then be changed to skim milk. If this is not available it should be continued on whole milk. A calf will do better not to receive whey for five to six weeks. It will take ten days to two weeks more to complete the change to whey. Calves will handle about the same amount of whey as skim milk, viz, 14 to 16 pounds daily per calf. An excessive amount may cause undue largeness of the paunch. The feeder will need to give more care and attention to calves fed on whey than to those fed milk.

Calves, like other farm animals, get thirsty, even though milk forms a large part of their ration. Calves three months of age will drink as much as 5 quarts of water daily per head. They like to drink often, sipping a little at a time. A half barrel, cleaned and replenished twice daily, will serve nicely as a water trough. Another good device is an automatic waterer, which may he easily cleaned, situated a little above the floor to keep out the litter. Salt is essential to the development of the calf, as of other animals, and should be kept continually available.

The management of the calf during the first year has much to do with its later usefulness. Plenty of water and salt should be given in clean vessels. Avoid sudden changes of diet and practice regularity in feeding. Provide warm, dry quarters in damp weather. Give plenty of roughage and not too much grain so as to develop a large capacity for handling food as is desirable in dairy animals. When the calf is six months to a year old milk may be omitted from its ration and a full roughage and grain diet substituted.

When the skim milk diet is stopped at any time from 6 to 12 months of age, it should be remembered that the calf is deprived of a nitrogenous feed and its place should be taken by some nitrogenous grain or roughage. The tendency of the dairy calf to get too fat depends not only upon its temperament but also upon its feed. Avoid too much corn. For grain, oats and barley are good; for roughage, bright clover or alfalfa hay with corn silage to give succulence and variety.

Size depends much upon heredity but even more upon liberal and judicious feeding. It is impossible to starve good dairy qualities into a growing heifer but many a promising heifer has been starved into a poor cow.

The intelligence that the herdsman puts into his calf feeding will have a great influence upon the future cow. There are great possibilities in the production of good cows but these are seldom if ever seen, appreciated, or attained except by an intelligent, thoughtful feeder. The earmarks of an intelligent feeder are seen in his herd. The calves are thrifty, active, with bright eyes, smooth, glossy coats, always hungry, and playful and lusty.

DEFECTS IN COTTAGE CHEESES.[a]

Methods of making cottage cheeses were described in a previous bulletin of this series.[b] The common defects in cottage cheese, and their causes and remedies,[c] are summarized in a bulletin of the New York Cornell Station substantially as follows:

Defects in flavor.—Unclean, bitter, acidy, and food flavors due to bacteria which gain entrance in one or more of the following ways: Unclean milk supply, unclean utensils, on dirt carried by flies, impure starters, development of acid, and to strong-smelling foods which the cows have eaten. It is practically impossible to make the cheese any better than the milk supply. Many undesirable flavors can be avoided, however, by pasteurizing part or all of the skimmed milk and ripening with a good commercial starter.

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[a] Compiled from New York Cornell Sta. Buls. 257, 270.

[b] U. S. Dept. Agr., Farmers' Bul. 202, p. 28.

[c] See also U. S. Dept. Agr., Farmers' Bul. 92, p. 25.

Defects in texture.—The most common defects are dry, mealy, and lumpy texture due to too little moisture or an uneven incorporation of moisture in the cheese as a result of too high or uneven temperature during the manufacturing process, which usually occurs in cold weather in buildings where the temperature can not be controlled, overdevelopment of acid, too rapid drying or uneven drying, use of too much rennet, or uneven coagulation.

> If uniform results are to be obtained the temperatures and acidity must be uniformly controlled. In cold weather the building should be warm. The use of an acidimeter affords an accurate means of determining the amount of acid at all times, and when this is known the development can be controlled by raising or lowering the temperature as desired. Lactic acid forms most rapidly at 90° F., and as this temperature is lowered the growth of lactic acid forming bacteria is checked proportionally. An important fact to remember is that the lower the temperature and still have a proper coagulation the smoother will be the texture.

The cheese is also sometimes soft, pasty, or mushy in texture, due to too much moisture in the cheese resulting from too low temperature of coagulation, imperfect coagulation, or insufficient drying. The precautions given under dry texture apply here as well.

> The great secret of successful cottage cheese making lies in the proper controlling of temperature, acidity, and moisture during the entire manufacturing process. A high moisture content means more whey and therefore more milk sugar, and subsequently a greater and more rapid formation of acid. In dry cheese the formation of acid is slower.

All soft cheeses should be wrapped in parchment paper and tinfoil. When the wrapping in parchment paper is omitted the cheese is contaminated with the tin.

The bulletin makes the following suggestions regarding the importance of quality in cheese in general:

> The finished cheese can be no better than the milk from which it is made. Every cheese maker should be familiar with the use of the acidimeter and the fermentation test. The cheese factory should be the center of rural dairy education. The maker should be qualified to teach his patrons. If the factory building is neatly painted, if the surroundings are tidy, and if the maker himself has a good appearance, it will be easier to induce the patrons to furnish better milk. It will be of much greater value to the cheesemaker, the patron, and the consumer if in the future more attention is given to the improvement of quality rather than quantity.

THE IOWA SILO.[a]

For several years the Iowa Station has been making a careful study of modern silo construction and of the success and merits of different types of silos. A bulletin, issued first in 1908 and reissued in 1909, treated of types of silos then in use and presented a design of a new type of silo constructed of hollow clay building blocks. A more recent bulletin of this station, by J. B. Davidson and M. L. King, describes in detail the construction, merits, and success of this silo, which has come to be known as the Iowa silo. In brief, the materials used in the construction of this silo are rectangular hard-burned (vitrified) hollow clay building blocks (fig. 1), which do not readily absorb water; a rich, water-tight mortar, and a cement wash for the inside of the wall; and enough steel reinforcement (hard black No. 3 or No. 9 steel wire) laid in the mortar joints of the silo to resist a bursting pressure of silage of 30,000 pounds per square inch. The doors, either individual or continuous, are constructed of wood as described later. The roof may be of concrete, wood, metal, or other material.

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[a] Compiled from Iowa Sta. Bul. 117.

In constructing the silo it is of great importance to have a foundation sufficiently broad to prevent appreciable settling and deep enough to avoid danger from freezing. A depth of 3½ feet is recommended. If there is any probability of ground water standing about the foundation a tile drain should be laid as shown in figure 3.

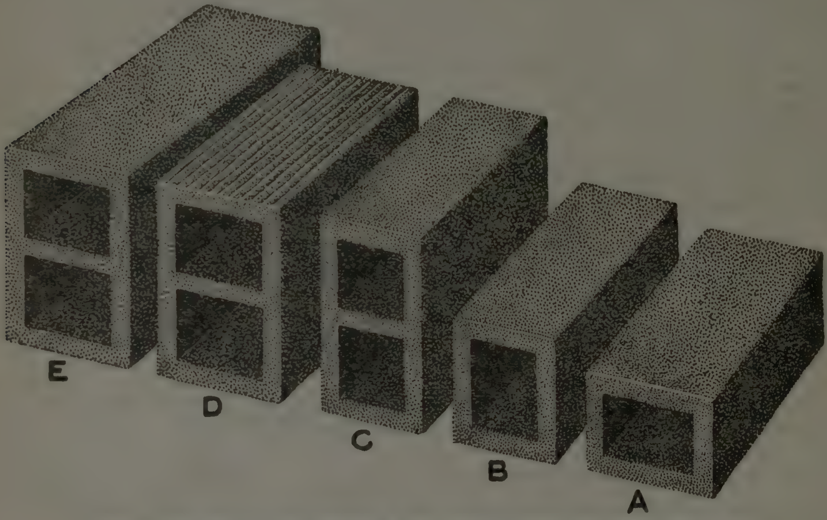

FIG. 1.—Five sizes of hollow vitrified clay building blocks used in silo construction.

"Porous back filling placed outside the foundation insures that any surface or ground water will sink to the drain rather than fill the blocks of the wall through any crevice which may exist."

The foundation may be one of at least four types: "(1) Building blocks throughout; (2) concrete footing with blocks extending from the floor up; (3) concrete footing with blocks laid on end and filled with concrete; (4) concrete footing and foundation extending to about 1 foot above the grade line." In the first type, shown in figure 2—

> The first course of the footing is 16 inches wide, made of two 8-inch blocks laid flatwise side by side. Then the next course, 12 inches in width, should consist of blocks laid flat crosswise and bedded in mortar. This completes the footing and the third course becomes the first course of the wall. The third and each succeeding course

should be liberally mortared or plastered at the outside of the vertical joint. This reduces the liability of water getting into any course of the foundation. The lower course if connected to a drain would render any other drainage unnecessary.

[The second type] of foundation simply consists of a concrete footing which is placed in a trench at the bottom of the pit, 12 inches or one spade deep, 8 inches or one spade wide at the top, flared to 16 inches in width at the bottom. On the top of this footing is placed the wall built of blocks. (See fig. 3.)

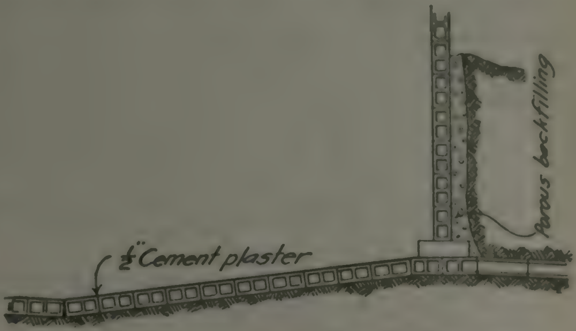

FIG. 2.—Foundation constructed entirely of building blocks.

These two foundations have the advantage of not requiring forms for their construction. The choice between them depends upon their relative cost. When sand and gravel are expensive the first is the cheaper.

Perhaps the greatest objection that can be foreseen to these two forms of foundation is the possibility of the blocks of the wall filling with water, which through carelessness or faulty drainage might be standing against the wall. * * *

In order to prevent any such trouble, the outer joints may be left open at a point directly under the roof down spout, at which point there should of course be special provisions for carrying away all surface water which may collect. This may be easily accomplished by filling over an opening in the drain tile with coarse material, which will always permit the passage of surface water directly and quickly to the drain.

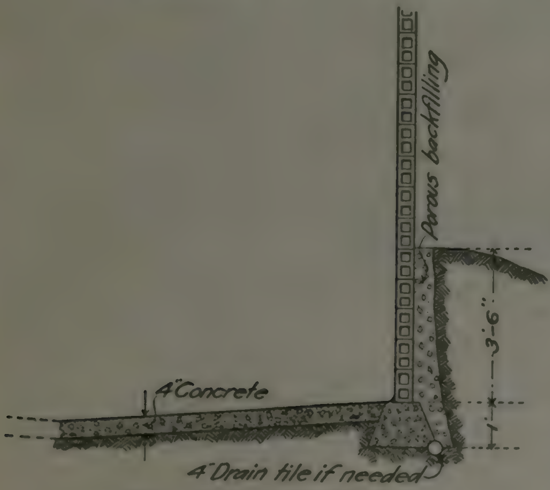

FIG. 3.—Second type of silo foundation.

[The third] type of foundation shown in figure 4 is built with a concrete footing upon which blocks are placed on end, each course being filled with concrete as it is placed and another course placed and filled in a similar manner. This method is continued to a point at least a foot above the grade line. From this point up the blocks are laid horizontally. The advantage of this type is that the possible danger from water is obviated. More expense and work is incurred, although no material for forms is necessary.

[The fourth] type of foundation is shown in figure 5. Earth is utilized for the outer form but lumber is used for the inner. By permitting this to extend down only to within a few inches of the bottom of the pit, the footing may be permitted to widen. This is desirable as a wall need never be as thick as the width of the footing. In case the ground is reasonably level and firm, it will be cheaper to simply dig a narrow trench and widen same at bottom to 16 inches. If ground is excavated next day and concrete trimmed, a reasonably smooth job is insured.

The floor of the silo may be constructed out of ordinary concrete used in sidewalk construction and need not be more than 3 to 4 inches thick. For convenience and economy it should be slightly hollowed in the center. Where the silo is built on heavy clay or other nonporous soil and the foundation is deep enough to keep out rats no floor will be necessary, although usually a floor is desirable.

If properly graded sand and gravel can be obtained, one part of cement to five parts of sand and gravel will be about the right proportion to use. The concrete should be thoroughly tamped and troweled.

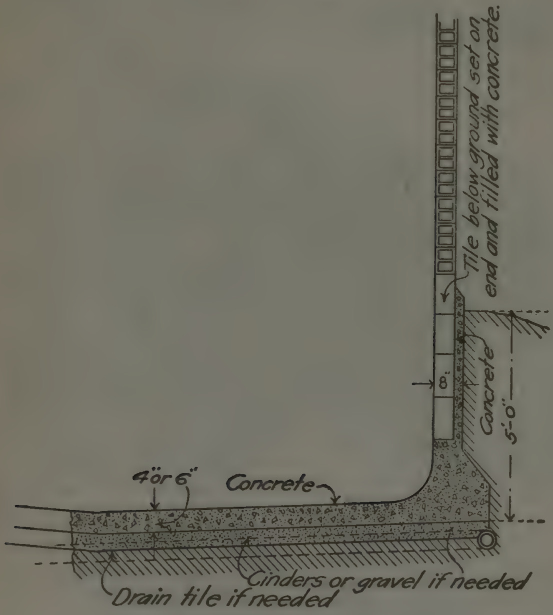
Tile below ground set on end and filled with concrete
8"
3"
Concrete
5'-0"
4" or 6"
Concrete
Cinders or gravel if needed
Drain tile if needed

FIG. 4.—Third type of silo foundation.

In some cases where sand and gravel are expensive, it may be cheaper to use a clay sidewalk block or even a hollow block, the same as used in the wall, covered with a thin coat of plaster. In the case of the sidewalk blocks, the plaster covering would be unnecessary if the blocks were laid in cement.

There is decided advantage in using curved blocks for the construction of the walls, and such blocks can be made without any great difficulty. "A workman lays up the curved block more rapidly and with more satisfaction than the straight block. The wall is smoother inside and out, which is of obvious advantage to the preservation of silage inside and the appearance outside."

Five different sizes of blocks, as shown in figure 1, may be used, but the type C, in the figure, has many advantages over the other kinds "as it forms a 4-inch wall which is abundantly strong for the purpose and each block forms an 8-inch portion of the wall. With this block less mortar is required than with any other size block." * * *

Also it forms a warmer wall than the smaller size blocks, as there is less material extending across the wall to conduct heat away from the warm silage. It is also easier for the mason to handle as he can grip it in one hand conveniently, while a larger block is tiresome to handle. Also in turning a circle with a thicker block, the outer joint stands open proportionately farther. In addition to this, it has the advantage of being more easily bent than a larger block, and costs less as such material is sold by volume. * * *

The mortar used for this work is composed of cement, lime, and sand. The sand should be medium fine. A certain amount of lime is necessary, as cement mortar is not plastic enough to stick to the ends of the blocks when applied. No more lime should be used than necessary to make the mortar workable. The quantity of lime for this purpose will vary somewhat with the material and workman. Perhaps the least amount of lime which could be made to serve the purpose is one part of cement, one-third of one part of lime, and two parts of sand, while one part of cement, one part of lime, and four parts of sand is as much lime as would ever be required and at the same time provides a mortar of good quality. The hydrated lime generally sold in paper sacks is a very convenient form of lime to use, as it can be mixed dry with the cement and sand. Enough may be mixed dry to last one-half day, then wet down as it is needed. The importance of measuring all materials and thoroughly mixing them can not be emphasized too strongly. Thorough mixing is absolutely essential for a smooth mortar. Very few men can make a uniform quality of mortar without measuring the materials.

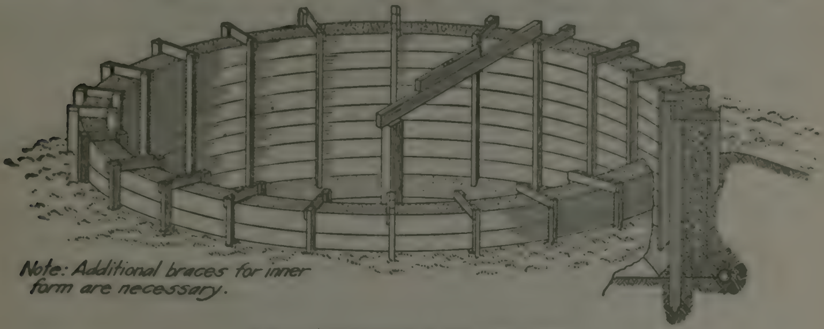

FIG. 5.—Fourth type of silo foundation.

In order that cement mortar may set properly, it must contain considerable water. If this water is drawn out by coming in contact with hot, dry blocks, the mortar can not harden properly. A hard block will of course absorb less moisture than a soft one, but both hard and soft blocks, if warm, should be dipped for a few moments just before laying.

The most convenient and advantageous place for the reinforcement in this type of a silo is in the mortar joints. The size of steel necessary is less than the thickness of the mortar joint; therefore, it does not interfere with the laying of the blocks and, by placing it in the mortar joint, it is thoroughly protected from rust. The amount of steel necessary is shown in figure 6, and the size of wire most suitable will vary with the size of the silo and its availability. Heavy wires are not generally carried in stock, therefore a decision in regard to the size to be used should be made and the order placed at least a month before building. It is hoped that the demand will cause manufacturers to carry a sufficient supply to be able promptly to furnish silo builders with material. The size of the wire most convenient to use is No. 3, which is ¼ inch in diameter. This is as large as can be handled in the mortar joints conveniently, but it is not larger than necessary. Even with this size of wire it is necessary in the case of large silos, and 8-inch blocks, to place more than one wire in each mortar joint near the bottom. However, if convenient to purchase, it will sometimes be advantageous to purchase No. 6, 8, or 9 wire for the upper portion of the silo where less reinforcement is necessary. The wire, when embedded in the mortar, will not rust, therefore black wire should be used as it is cheaper than galvanized. All wire should be stored in a dry place where it will not rust. The most desirable quality is hard or high-carbon wire. Soft or medium wire is difficult to straighten and kinks badly in handling, thus causing considerable trouble. Hard or high-carbon wire is as cheap as any, more convenient, and stronger. These heavy wires are wound in coils, therefore it becomes a very important problem to straighten them sufficiently to lay on the wall.

In figure 6 is shown the number of wires No. 9 or No. 3 which should be placed in each mortar joint of any silo varying in diameter from 12 to 20 feet and 40 feet or less in height, with mortar joints 5 and 8 inches apart. The left half of the plate is for mortar joints placed 8 inches apart while the right half is for joints 5 inches apart. Most standard material is such as to be laid in one of these two ways. The top row of figures on either side of the plate indicates diameters. The left figure of the double column below each large figure indicates the number of No. 9 wires while the right of the double column indicates the number of No. 3 wires for each joint. The distance from top of silo should be the basis of calculation at all times.

In practice, the table would be used as follows: For example, take a 16 by 36 silo made of 4 by 8 by 12 blocks, reinforced with No. 3 wire. In the left half of the table under 16 at a depth of 36 feet is found mortar joint No. 54 which should contain two No. 3 wires. Succeeding joints should be reinforced as indicated in this column successively above.

The most convenient method tried for straightening this wire * * * may be described as follows: Secure or build a reel from which a coil of wire may be conveniently unwound. Mount this reel upon a plank or platform where it will turn easily, then secure a short piece of gas pipe close to the reel as shown in figure 7.

Through this pipe draw the wire as it uncoils from the reel. The pipe should be so placed that its curvature will be the reverse of the curvature of the wire in the coil. At a convenient distance from the pipe, drive a stake, at which point the wires may be cut to their proper length. In order to determine this length easily, another stake may be driven to which the end of the wire may be pulled each time before cutting. As soon as the first wire is cut, it should be laid upon the wall or fitted to a similar sized circle to see if the curvature is correct. If not, the curvature of the pipe may be altered and, by a few trials, the proper curvature secured.

The horizontal or bed joints should be thoroughly bedded to cover the steel reinforcement. The vertical joints at the block ends should be made with extreme care in order to insure perfect air and water-tight joints. In order to do this the ends of both blocks should be mortared before pressing together. * * *

The outside joints should, for the sake of appearance, be struck neatly with the trowel as the work progresses, and for warmth they should of course all be tight. On the inside, however, this is scarcely sufficient, as there might still be an occasional opening left between the ends of the blocks, which would permit the air to enter. In order to close all such openings, the mortar may be left hanging on the inside or cut roughly, then while still green washed with a cement wash before the scaffold is raised or the work left for the night. This wash naturally brings to view any crevices which may exist. These may then be filled with mortar, and this thoroughly seals the inside of the wall. This wash is composed of cement and water mixed to about the consistency of good paint and can be applied with a broom. The wash should be applied vigorously in order to smooth down and fill the irregularities.

The blocks should be carefully examined as to quality, and "only unquestionably good blocks should be put in the ground or near the grade line."

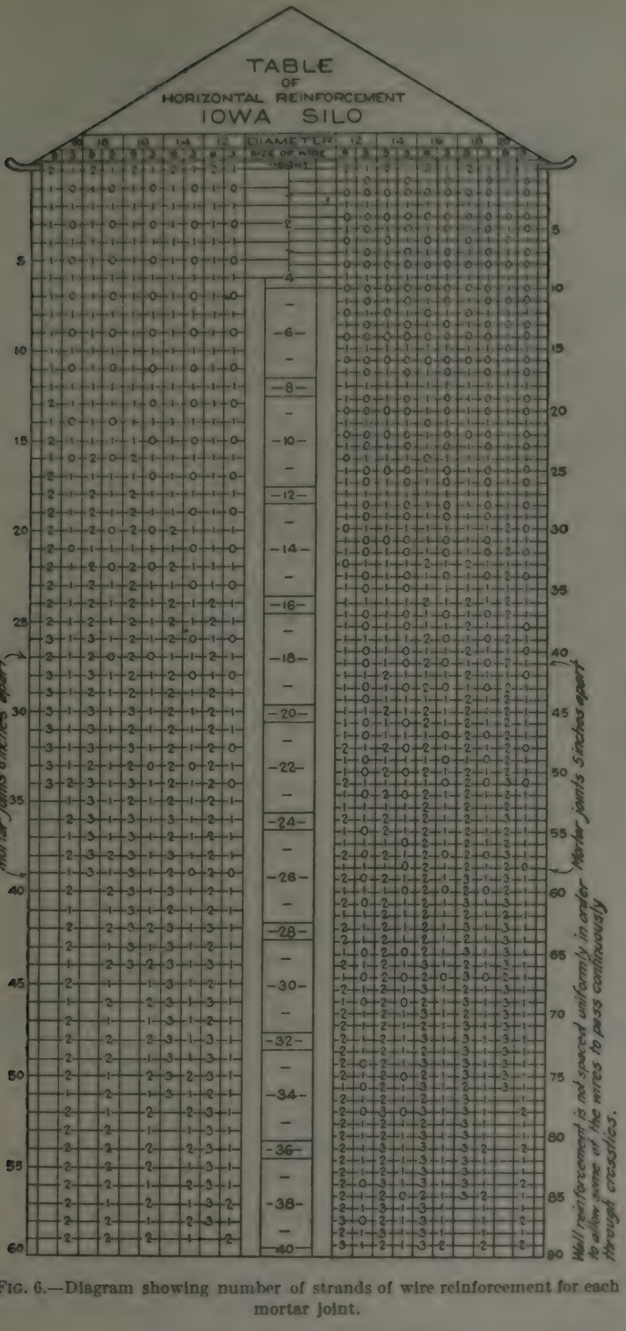
TABLE
OF
HORIZONTAL REINFORCEMENT
IOWA SILO
DIAMETER
SIZE OF WIRE
HEIGHT
Mortar joints 8 inches apart
Mortar joints 5 inches apart
Wall reinforcement is not spaced uniformly in order to allow some of the wires to pass continuously through crossties.

FIG. 6.—Diagram showing number of strands of wire reinforcement for each mortar joint.

All questionable blocks, if used at all, should be put in the top few feet of the structure. The medium quality should be used for the main wall. A quality of block which would be entirely satisfactory for portions of the wall above the foundation might not be permissible for foundation work on account of the moisture present on the outside near the grade line. However, it must be remembered that it is always best to get unquestionable material for the whole silo even though the cost of the material or freight be considerably more.

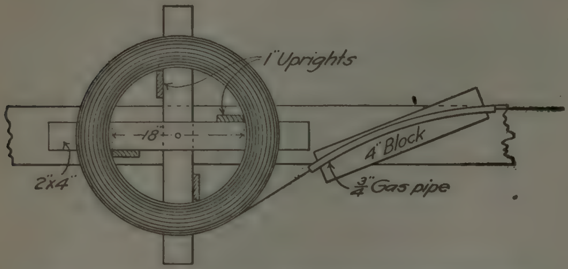

FIG. 7.—Reel and device for straightening wire reinforcement.

The following method of laying the wall, which is considered only one of several practical methods, has been successfully used:

The first course should be spaced around one-eighth to three-sixteenths of an inch apart without mortar in order to determine the proper diameter of silo and length of guide. This will overcome the necessity of cutting blocks. Steel should be placed upon the outer half of courses in order that there shall be enough mortar inside to bear against the wire and hold the blocks. Loose blocks may be placed temporarily upon the wall to hold the steel in place at intervals of 6 or 8 feet as occasion requires. Steel upon the courses below and above the doorways should be long enough to lap past each other and be hooked as shown in figure 8.

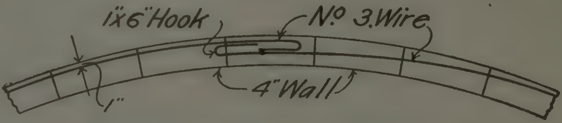

FIG. 8.—Method of lapping wall reinforcement.

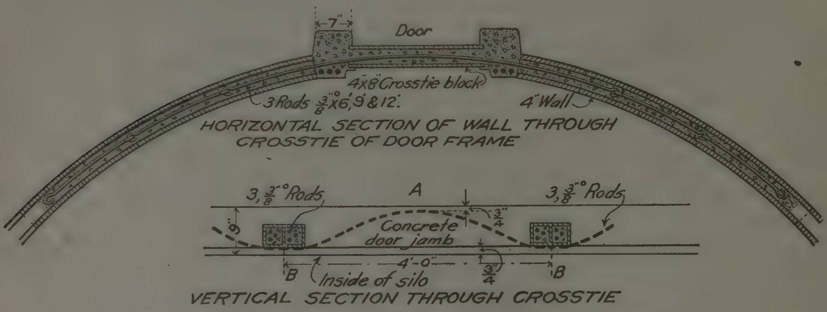

FIG. 9.—Section of wall and cross-tie for continuous door frame.

Two types of doorways, the individual and the continuous, have been successfully used. The continuous doorway is more convenient and is generally more desirable.

In the individual doorway the size of opening is 32 inches wide by 34 to 36 inches high, depending somewhat upon the size of the blocks, of which three or four courses are placed between the doors. The continuous doorway is 22 inches wide by 40 to 48 inches high. It consists essentially of a continuous door jam on each side of the opening.

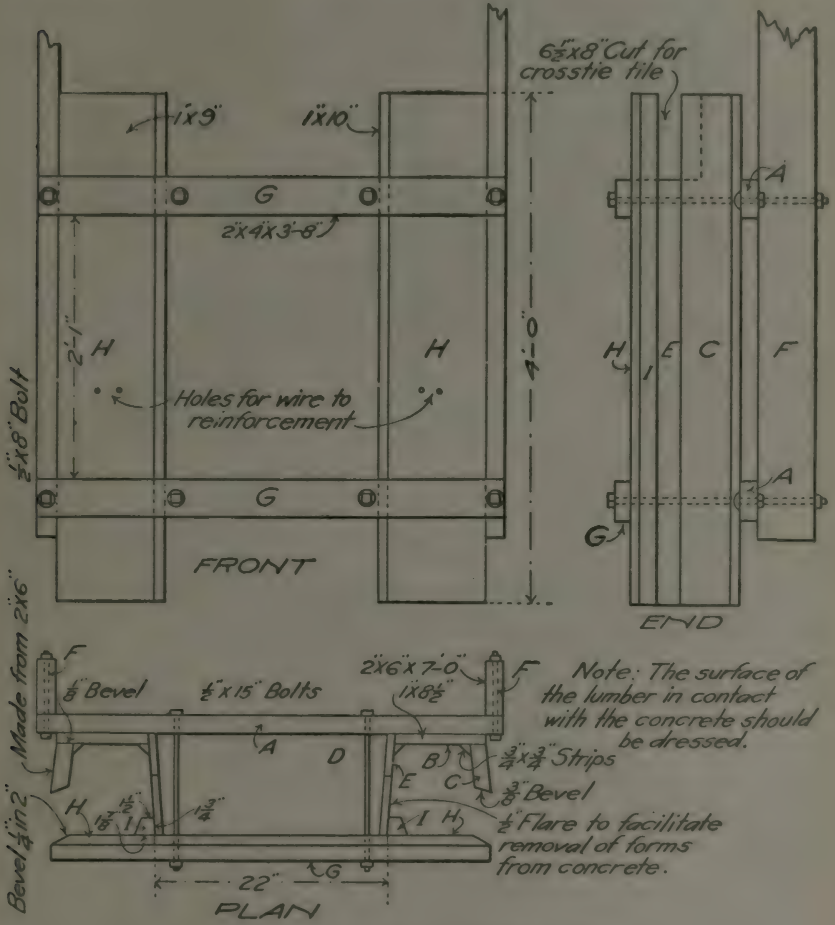
6½"x8" Cut for crosstie tile
1"x9"
1"x10"
G
2"x4"x3'-8"
2'-1"
H
H
Holes for wire to reinforcement
4'-0"
½"x8" Bolt
G
FRONT
A
H
I
E
C
F
A
G
END
Made from 2"x6"
F
⅛" Bevel
½"x15" Bolts
2"x6"x7'-0"
1"x8½"
F
Note: The surface of the lumber in contact with the concrete should be dressed.
A
D
B
C
E
¾"x¾" Strips
⅜" Bevel
½" Flare to facilitate removal of forms from concrete.
Bevel ¼" in 2"
H
1⅞"
½"
I
1¾"
I
H
22"
G
PLAN

FIG. 10.—Forms for continuous concrete door frame.

These jams are made up of reinforced concrete. The horizontal reinforcements of the silo wall hook into the vertical reinforcements of the jam. The jams are tied together at intervals of 4 or 5 feet by steel within the crosstie blocks. This steel not only extends into the vertical jam, but in order to be more secure, extends several feet into the wall on either side of the jam.

These crossties may be built, as shown in figure 9, of steel protected from rust by being incased within the clay blocks filled with concrete or concrete alone.

A detailed drawing of the form used for the continuous doors is given in figure 10. The form, scaffold, and guide used in building the silo wall and doorway are shown in place in figure 11.

The doors to fit the individual doorway must be curved and may be made as shown in the drawing, figure 12. Two cleats may be sawed to the proper curve and two thicknesses of 6-inch fence flooring nailed to the inner side of the curve, between which should be placed a layer of tar paper. The cleats should not reach closer than within 1½ inches of side of the door, as a 1½ inch bearing will be necessary between the door and the concrete door frame.

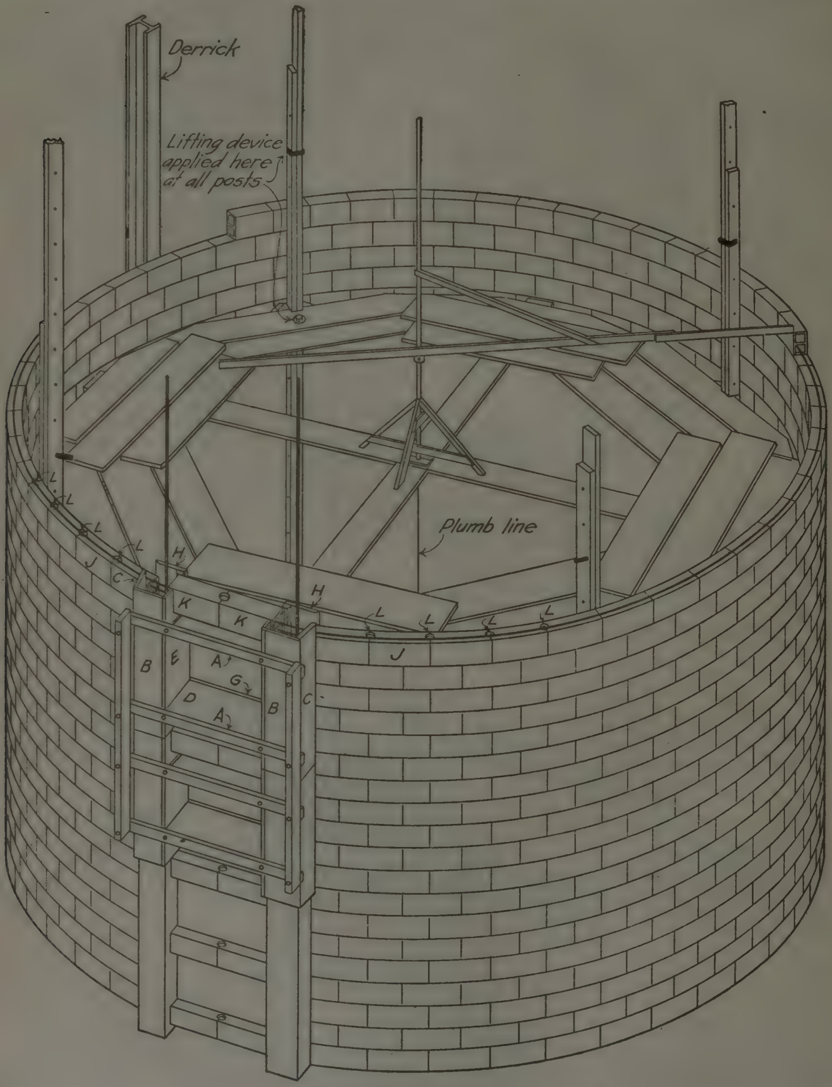

FIG. 11.—Form, scaffold, and guide used in building silo wall and doorway.

Two principal kinds of doors have been successfully used in the continuous doorway. Figure 13 shows a door made of two thicknesses of fence flooring crossed with tar paper between. These doors are beveled at the end to set loosely into the beveled shoulder in the concrete.

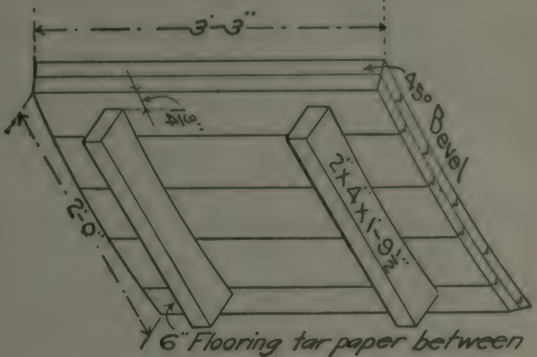

FIG. 12.—A form of individual door.

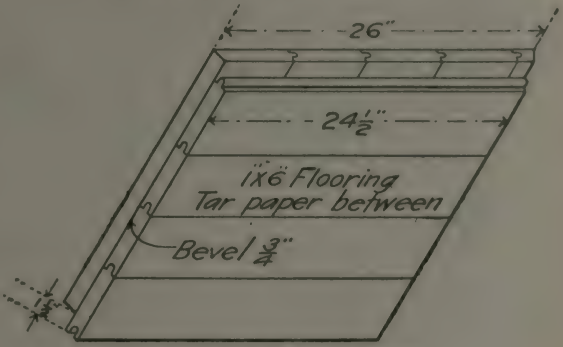

FIG. 13.—A form of continuous door.

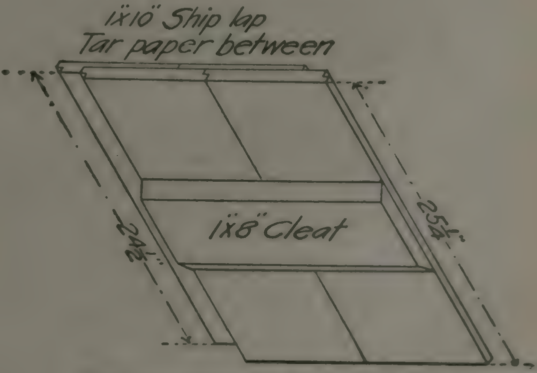

FIG. 14.—A cheaper form of continuous door.

A cheaper and very good door is shown in figure 14. This door as shown is made of two thicknesses of shiplap, that lap onto each other about 2 inches and are not beveled at the ends. The boards on the outer side are shorter than those on the inside. A wide cleat with beveled edges is nailed to the inner side of the door and on the different doors meet end to end, thus offering little obstruction to the free settling of the silage.

In order that any silo may fulfill its purpose, it is necessary that the joints between the doors and the door frames be air-tight. * * * Sealing with clay was found to be satisfactory where reasonable care was exercised in its use. This becomes a very simple matter by taking a quantity of fine clay, wetting it until sticky but quite stiff, and filling the shoulder of the door frame with this before pressing the door into place. If the mud is rather stiff it will hold the door to place until the silage is up high enough to secure it permanently. The moisture of the silage keeps the clay damp on the inside, thus making it air-tight.

While a roof is not absolutely necessary, it is desirable for a number of reasons. It may be built of concrete, wood, metal, or other material, but concrete construction presents certain decided advantages and insures a building constructed throughout of equally durable material. A convenient method of constructing a concrete roof is described in detail.

The following is a bill of materials required for an Iowa silo 16 feet in diameter and 35 feet high with concrete roof:

This bill may be easily modified for other sizes. The different types of foundations, doors, etc., are included, from which choice may be made to suit condition.

Type one foundation:		
Blocks 4 by 8 by 12		130
Cement	sacks	1½
Lime	do	1½
Sand	yard	2/9
Type two foundation:		
Cement	barrels	2½
Gravel	yards	2
Type three foundation:		
Cement	barrels	5¾
Gravel	yards	4½
Type four foundation:		
Cement	barrels	6½
Gravel	yards	5
Material for forms—		
Stakes, 24 pieces, 2 inches by 4 inches by 6 feet	board feet	98
Stakes, 24 pieces, 2 inches by 4 inches by 2 feet	do	32
Braces, 24 pieces, 2 inches by 4 inches by 10 feet	do	160
Sheeting, ½-inch lumber	do	300
Floor:		
Cement	yards	2
Gravel	barrels	2½
Wall:		
Blocks, 4 by 8 by 12		[a] 3,000
Freight on 18 to 24 tons.		
Cement	barrels	5
Lime	do	5
Sand	yards	2
Steel No. 3 wire, hard	pounds	400
18 pieces ½ inch by ½ inch by 18 feet reinforcing bars	do	276
No. 12 soft wire	do	5
Scaffold:		
Posts, 20 pieces, 2 inches by 6 inches by 16 feet	board feet	320
Frame work, 5 pieces, 2 inches by 8 inches by 12 feet	do	80
Plank below scaffold, 2 pieces, 2 inches by 8 inches by 16 feet	do	44
Platform, 2 pieces, 2 inches by 12 inches by 14 feet	do	56
Platform, 2 pieces, 2 inches by 10 inches by 16 feet	do	54
Platform, 6 pieces, 2 inches by 12 inches by 16 feet	do	192
Platform, 4 pieces, 1 inch by 12 inches by 16 feet	do	64
Braces for holding post before wall is started—		
8 pieces 1 inch by 6 inches by 16 feet	do	64
4 wire stretchers.		
4 clevises.		

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[a] In case type 4 foundation is used, the number of blocks will be about 150 to 200 less.

Forms:		
Individual door form—		
Lumber, 2 pieces, 2 inches by 6 inches by 10 feet	board	20
Lumber, 1 piece, 2 inches by 6 inches by 16 feet	do	16
Lumber, 1 piece, 2 inches by 4 inches by 14 feet.		
Lumber, 2 pieces, 2 inches by 4 inches by 12 feet	do	25
Lumber, 4 pieces, 1 inch by 10 inches by 14 feet.		
Lumber, 1 piece, 1 inch by 10 inches by 14 feet.		
Lumber, 2 pieces, 1 inch by 10 inches by 16 feet	do	88
Eight ½ inch by 10 inches machine bolts.		
Eight ½ inch by 17 inches machine bolts.		
Continuous door forms—		
Lumber, 1 piece, 2 inches by 4 inches by 8 feet.		
Lumber, 2 pieces, 2 inches by 4 inches by 14 feet	do	24
Lumber, 2 pieces, 2 inches by 6 inches by 16 feet	do	32
Lumber, 4 pieces, 1 inch by 10 inches by 14 feet	do	47
Lumber, 1 piece, 1 inch by 10 inches by 8 feet	do	7
Eight ½ inch by 7 inches machine bolts.		
Eight ½ inch by 15 inches machine bolts.		
Guide:		
¾ inch by 1½ inches by 14 feet stop.		
2 pieces 4 feet lath.		
2 inches by 4 inches by 8 feet	feet	5⅓
8 feet gas pipe 3 inches or 1 inch.		
Derrick:		
3 pieces 2 inches by 6 inches by 16 feet	board feet	48
1 piece 2 inches by 6 inches by 6 feet	do	6
6 pieces 1 inch by 6 inches by 16 feet	do	48
3 guy wires (100 feet each) No. 9 wire	pounds	20
Individual doors (six are required):		
Fence flooring	board feet	96
2 by 4 cleats	do	16
Tar paper or prepared roofing	square yards	6
8d nails.		
Continuous doors:		
Fence flooring	board feet	152
Tar paper or prepared roofing	square yards	10
6d nails.		
Continuous doors:		
10 inch shiplap	board feet	172
Tar paper or prepared roofing	square yards	10
6d nails.		
Roof:		
Cornice blocks—		
Cement	barrels	1½
Sand	cubic yards	¾
Steel No. 9 wire	pounds	10
Form for cornice blocks—		
1 piece 1 inch by 8 inches by 3½ feet	board feet	8⅓
1 piece 1 inch by 6 inches by 12 feet		
1 piece 2 inches by 4 inches by 7 feet	board feet	5
Lever for setting—		
1 piece 2 inches by 4 inches by 8 feet	board feet	5⅓

Roof—Continued.		
Cement	barrels	5
Gravel	yards	2
Steel, 3 pieces ½ inch by ½ inch by 18 feet	pounds	46
False work:		
26 pieces 1 inch by 12 inches by 10 feet sheeting	board feet	260
8 pieces 2 inches by 6 inches by 10 feet rafters	do	80
1 piece 4 inches by 4 inches by 6 feet or 1 cedar post	do	8
5 pieces 1 inch by 8 inches by 16 feet	do	54
4 pieces 1 inch by 6 inches by 16 feet	do	32
8 forgings.		

The following estimate of labor required for the construction of an Iowa silo "is based upon the use of 4 by 8 by 12 curved blocks, and a silo 16 feet diameter and 35 feet high with concrete roof. By modifying this estimate to suit any other size of silo or local labor conditions, a quite definite idea of labor cost may be obtained."

Excavation:
- 4 men 5 hours.
- 1 team 5 hours.

Footing:
- Type one—
  - Mason 3 hours.
  - Mason helper 3 hours.
  - Unskilled labor 3 hours.
- Type two—
  - Mason 4 hours.
  - Mason helper 4 hours.
  - Unskilled labor 4 hours.
- Type three—
  - Mason 6 hours.
  - Mason helper 6 hours.
  - Unskilled labor 6 hours.
- Type four—
  - Labor on concrete and forms.
  - Mason 15 hours.
  - Mason helper 15 hours.
  - Two unskilled laborers 15 hours each.

Floor:
- Mason 5 hours.
- Mason helper 5 hours.
- Two unskilled laborers 5 hours each.

Individual door forms: Carpenter 20 hours.

Continuous door forms: Carpenter 15 hours.

Scaffold:
- Carpenter 10 hours.
- Unskilled laborer 10 hours.

Wall:
- Mason 60 hours.
- Mason helper 60 hours.
- Two unskilled laborers 60 hours each.

Doors:
- Individual type: Carpenter 6 hours.
- Continuous type: Carpenter 5 hours.
- Continuous type: Carpenter 3 hours.

Roof:
- Cornice blocks making—
  - Mason 5 hours.
  - Mason helper 5 hours.
  - Unskilled laborer 5 hours.
- Cornice block setting—
  - Mason 6 hours.
  - Mason helper 6 hours.
  - Two unskilled laborers 6 hours each.
- Framing false work: Carpenter 6 hours.
- Placing false work—
  - Mason 3 hours.
  - Mason helper 3 hours.
  - Two unskilled laborers 4 hours each.
- Placing concrete—
  - Mason 8 hours.
  - Mason helper 8 hours.
  - Two unskilled laborers 8 hours each.
- Removal of false work and scaffold: Three unskilled laborers 6 hours each.

Issued March 11, 1911.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 431.

THE PEANUT.

BY

W. R. BEATTIE,
Assistant Horticulturist, Bureau of Plant Industry.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., December 24, 1910.

Sir: I have the honor to transmit herewith a manuscript entitled "The Peanut," by Mr. W. R. Beattie, Assistant Horticulturist, and recommend that it be published as a Farmers' Bulletin, to supersede the former publication, entitled "Peanuts", issued as Bulletin No. 356 of the same series. During the past two years the methods of production and the uses of peanuts have so changed and increased as to call for the issuance of a new bulletin.

The peanut is rapidly becoming an important farm crop throughout the Southern States. Its vines are valuable as forage and the peas that are not marketable can be used for feeding purposes. Throughout the boll-weevil district of the cotton belt the peanut promises to become of importance as a money crop, and special oil-producing varieties will doubtless assist in keeping the oil mills of the Southern States supplied with raw materials.

Respectfully,

Wm. A. Taylor,
Acting Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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THE PEANUT.

INTRODUCTION.

It is not definitely known when and where the peanut was first cultivated. Several allied species of plants are natives of Brazil, and there is every indication that the common peanut originally came from tropical America. Peanuts were introduced into the United States during the earlier days of colonization, but did not become of commercial importance until about 1870. From that time until 1897 the growth of the peanut industry was gradual, but a great increase in the production and use of peanuts has taken place during the last eight or ten years.

Botanically the peanut belongs to the same group of plants as do the beans and peas, but it possesses the character of maturing its fruit or nut beneath the surface of the soil rather than above ground, as do most other leguminous plants. The technical name of the peanut is *Arachis hypogea*, the name indicating the characteristic habit of the plant to mature its fruits underground. The peanut is known under the local names of "goober," "goober pea," "pindar," "ground pea," and "groundnut." The names "goober" and "goober pea" are more properly applied to an allied species having no true stem and only one pea in each pod which has been introduced and is frequently found growing wild in the Gulf Coast States. Properly speaking, the peanut is a pea rather than a nut, the term "nut" having been added on account of its flavor, which is similar to that of many of the true nuts.

The small yellow flowers of the peanut are borne in the little pocket where the leaves are attached to the stems, and as soon as pollination has taken place the visible portion of the flower fades and falls, after which the short, thick stem that supports the lower portion of the flower elongates and the sharp-pointed ovary is thrust downward into the soil, where the pod develops. Should the ovary fail to reach or penetrate the soil no pod will be formed.

The value of the commercial peanut crop of the United States for the year 1908 was estimated at $12,000,000. During recent years the area of production of peanuts has greatly increased, especially throughout the warmer parts of the country. The value of the peanut, both as a money crop and for feeding on the farm, renders it especially desirable as a part of the rotation wherever conditions suitable to its development exist.

Most persons think of the peanut as it appears for sale at the news and fruit stands, but during recent years many new lines of consumption have been found. In addition to the great quantity of peanuts sold in the shell each year, thousands of bushels are shelled for use in the manufacture of confections and food products.

It is the purpose of this bulletin to give full cultural directions for growing this crop, together with some of the uses of the peanut. The peanut is well adapted for use as a part of the cropping system in the Southern States, especially on the cotton and tobacco lands. Soils that will not produce more than one-fourth of a bale of cotton to the acre can be made to yield a fair crop of peanuts at a very low cost for growing. Comparatively few persons realize the value of peanuts when used as a farm crop, especially when the product is fed to live stock on the farm and eventually returned to the soil in the form of manure.

SOIL AND CLIMATIC REQUIREMENTS OF THE PEANUT.

The soil best suited to the peanut is one of a sandy, loamy nature, preferably light or grayish in color rather than dark. Soils that are dark and those carrying a considerable percentage of iron or other mineral are likely to stain the shells of the peanuts, thus rendering them less desirable for the trade. For use on the farm, however, the staining of the shells is of little consequence, as it does not materially injure them for stock feeding. In fact, soils that contain considerable clay and lime or are loamy in character produce heavier nuts and sometimes greater yields than do lighter soils. As a rule the peanut does best on a sandy loam with a well-drained clay subsoil, but the crop may be grown under a wide range of soil conditions. Soils that become hard or compact are not adapted to peanut growing, owing to the inability of the pod stems or "pegs" to penetrate the surface.

Soils that are poorly drained or sour are not suited to the peanut. The ideal soil consists of a sandy loam containing a reasonable amount of humus, or vegetable matter, together with an abundance of lime. A soil having a suitable mechanical consistency is the first essential. Soils lacking in fertility can be improved by a proper cropping system or by the judicious use of manures.

The cultivation of the peanut for commercial purposes has until recently been confined chiefly to areas in Virginia, Tennessee, the

Carolinas, and Georgia. During recent years the industry has become established throughout the South Atlantic States and westward to and including California. The territory indicated by the dark portion of the map shown as figure 1 is for the most part adapted to the production of peanuts for consumption on the farm; over a large part of this section a good grade of marketable nuts can be grown. This area, it will be observed, is one within which the frost-free season is comparatively long, and much of the territory has a soil containing a large percentage of sand or alluvial matter, making it easily cultivated and well adapted to the peculiar habits of the peanut plant. There are undoubtedly many sections outside of the area indicated on the map (fig. 1) that can be profitably devoted to the production of peanuts for stock food, and a few regions where they can be grown commercially.

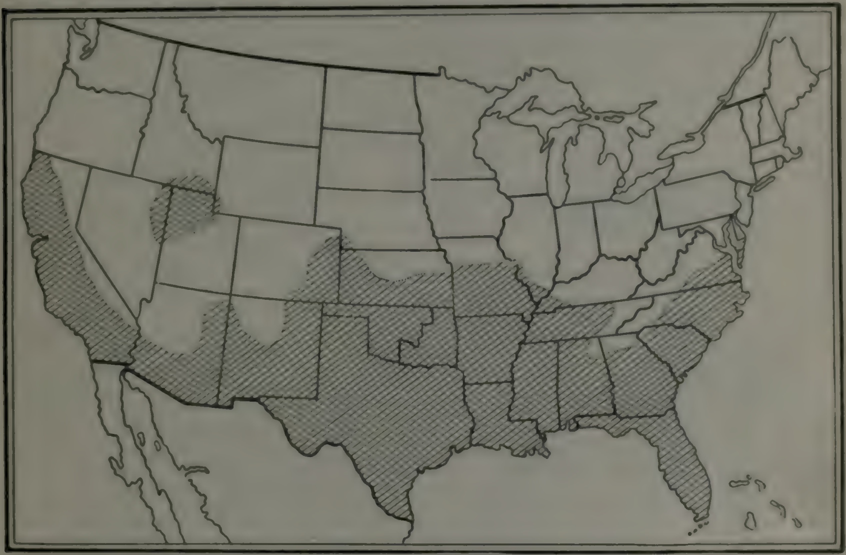

FIG. 1.—Map of the United States, showing the area adapted to the production of peanuts.

The climatic requirements of the peanut are a long season without frost, a comparatively light rainfall during the growing period, abundant sunshine, and a high temperature. The peanut is slightly more susceptible to injury from frost than the common bunch bean and requires a somewhat longer season for its development. The Spanish peanut will mature in ninety days under the most favorable conditions, but one hundred and ten to one hundred and twenty days should be allowed. The large-podded varieties require a longer period for best results.

PREPARATION OF THE SOIL.

Time for plowing.—The time for plowing the land to be planted to peanuts will depend somewhat upon its previous treatment. If the land has been in corn the previous season, and a soil-building crop planted in the corn, the plowing can be done during the winter or early in the spring after the cover crop has made considerable growth. Where the corn has been husked from the stalk and the stalks allowed to remain upon the ground, these, together with weeds and remains of the crop planted in the corn as a soil improver, should be dragged down and afterwards turned under with a disk plow. Any trash, such as corn or cotton stubble, remaining on the land will prove a menace to the cultivation of the peanut crop and it is essential that all such materials should be turned under in ample time to decay before planting the land to peanuts. If the land is in sod it will be desirable to break it during autumn or winter. If there is no crop on the land the plowing need only be done in time for planting or a short time before planting, in order to allow the soil to settle.

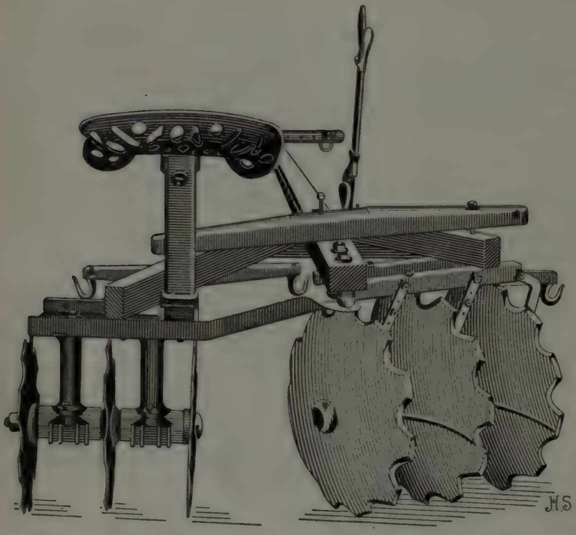

FIG. 2.—Disk plow adapted for fitting land for growing peanuts.

Depth of plowing.—The depth of plowing will depend somewhat upon the character and depth of the surface soil. On sandy soils that are underlain by a clay subsoil it would be unwise to bring a very great quantity of the subsoil to the surface. If the surface soil is not of sufficient depth, it should be increased by plowing a very little deeper each year until a sufficient depth is reached. As a general rule the depth of plowing for peanuts should be equal to that for corn in the same locality. From 5 to 7 inches of loose soil will be sufficient for the growing of all varieties of peanuts. Subsoiling may prove beneficial on soils having insufficient drainage.

Preparation for planting.—When the land is plowed but a short time before planting it should be harrowed within a few hours after plowing, in order to prevent loss of moisture. On loose, sandy soils that are reasonably free from weeds or grass it is often possible to dispense with the regular plowing and cut the land with a disk harrow or disk plow. A tool that is especially adapted for this purpose is shown in figure 2. This implement both cuts and turns the soil, leaving it in fine condition, so that it is readily prepared for planting.

Where plowing is necessary in order to turn under sod, clover, or weeds a tool of the type shown in figure 3 is desirable for smoothing and pulverizing the soil afterwards. This harrow is superior to the ordinary smoothing harrow in that it turns, crushes, and levels the soil in one operation. By means of a lever the cutting blades can be set to any depth, and the weight of a boy or light man upon the seat is sufficient to secure good work. If the soil is very loose it may be necessary to roll or drag thoroughly before planting.

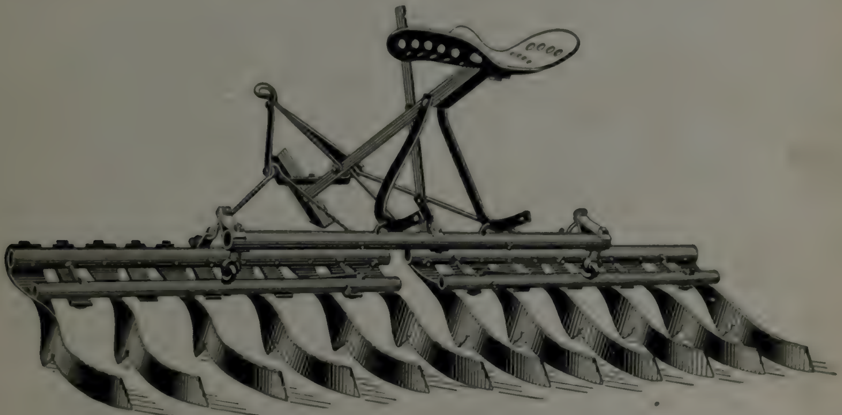

FIG. 3.—Harrow adapted for smoothing and pulverizing land.

Under ordinary circumstances level culture should be practiced, but where the drainage is poor it may be advisable to throw up slight ridges upon which to plant peanuts; this is especially desirable during a season of excessive rainfall. When ready for planting, the soil should be in the same general condition as that prepared for a crop of snap or bunch beans. Thorough preparation of the soil is profitable for all crops, and especially for peanuts. If the soil can be harrowed once a week for three or four weeks before planting, most of the weeds that would otherwise injure the crop will be destroyed.

FERTILIZERS AND PREPARATORY CROPS.

Cropping system and green manures.—Peanuts should be grown in rotation with other crops rather than as a specialty. The cropping system will depend somewhat upon the area of other crops grown, but the arrangement should be such that the land will be planted to peanuts one year in each three or four. A good rotation is corn or cotton the first year with cowpeas, crimson clover, or bur clover planted between the rows at the time of the last cultivation; the next season plow under the cover crop and plant the land to peanuts; as soon as the peanuts are harvested sow the land with rye and use as a winter pasture; plow under the rye during the springtime and plant cowpeas, using the peas as a hog pasture during the autumn; then return to corn or cotton the following year. In order to get the greatest benefit from a crop of crimson or bur clover it should remain on the land in the spring until a heavy growth has been made. It is not desirable to plant peanuts immediately after turning under a heavy growth of clover, and planting should be deferred until the land has had sufficient time to settle and the green manure to decay partially, or a rotation should be followed in which the peanuts do not come upon the land until the following year.

In the Gulf Coast States the rotation may consist of corn and cowpeas, followed by winter oats. The oats will ripen in June or early in July, in time to grow a crop of Spanish peanuts. The next season, plant cotton and sow crimson or bur clover at the time of the final cultivation. The following spring, the clover may be turned under, the land planted to corn, and the rotation repeated.

Another plan would be to devote the land one year to sweet potatoes or to a crop of early Irish potatoes followed by cowpeas. In this rotation stable manure should be applied to the crop of corn or cotton, and the commercial fertilizers with the peanut and potato crops. Peanuts should, if possible, follow some well-cultivated crop which has been kept free from weeds.

The use of stable manure.—Stable or barnyard manure should not be used as a fertilizer the same year that the land is planted to peanuts, owing to the great number of weed seed that are contained in the manure. The use of manure also has a tendency to cause the plants to produce abnormal tops and a large percentage of poorly filled pods, known to the trade as "saps" or "pops." The proper time for applying stable manure is with the crop grown the previous season, thus giving it time to become incorporated with the soil and reduced to the proper condition for the peanut crop.

Commercial fertilizers.—The peanut responds to the use of commercial fertilizers. However, a reasonable amount of humus in the soil is essential. If properly handled, the peanut crop is not exhaustive of soil fertility; in fact, the plant is a great nitrogen gatherer, as may be observed by the large number of nodules upon the roots. On the other hand, if the entire plant, including the root, is removed and no part returned to the soil the peanut becomes almost as exhaustive of soil fertility as corn. By feeding the straw and other refuse from the crop to cattle, hogs, and work animals and applying the manure thus obtained to the land the fertility may be retained or even increased.

The nitrogen-gathering bacteria are usually present in abundance, even where the crop is planted for the first time, but should the nodules not be abundant artificial inoculation would prove an advantage.

On soils that are adapted to the production of peanuts it will not be necessary to employ commercial fertilizers in large quantities. The alluvial and overflow lands found along the rivers of the Southwest seem to be well supplied with all the elements necessary for the production of peanuts. On the sandy hill lands of this region it will be necessary to add fertilizers and lime in varying quantities.

A commercial fertilizer adapted to the production of potatoes is as a rule suited for the growing of peanuts. A mixture which contains from 2 to 3 per cent of available nitrogen, 5 to 7 per cent of available phosphoric acid, and 6 to 10 per cent of potash is desirable; this should be applied at the rate of from 200 to 800 pounds to the acre, according to the needs of the land. Most growers follow the practice of scattering the fertilizer in a narrow strip where the row is to be planted, often using a one-horse fertilizer distributer for the purpose. It is important that the fertilizer be thoroughly mixed with the soil.

Importance of lime in the soil.—In order to insure the proper filling and ripening of the pods, peanuts require an abundance of lime in the soil. Where the soil is of a calcareous nature, containing limestone, shells, or lime in its more active form, it may not be necessary to make a regular application, but on soils that are deficient in lime or inclined to be in the least sour, from 600 to 1,000 pounds of fresh-burned lime should be applied to an acre every four or five years. The presence on the land of certain weeds, such as the common sorrel and the sedges (which have three-cornered stems), indicates sourness and insufficient drainage; to correct this an application of lime will be necessary in addition to ditching or tile draining. The lime should not be put on at the same time as the commercial fertilizers, but rather during the previous autumn, or at the time of plowing the land.

Where deposits of marl are found this may be used as a substitute for lime. In Virginia the marl is hauled and scattered broadcast upon the land during the winter months.

Wood ashes are desirable as a fertilizer for peanuts, as they contain both potash and lime. Unleached wood ashes may be applied broadcast at the rate of 1,000 to 1,200 pounds, 25 to 30 bushels, to the acre.

Lime should be used on land that is to be planted to peanuts, unless it is definitely known that there is an abundance of it already present. In the river valleys of the boll-weevil district there appears to be an abundance of lime present in the soil.

The peanut as a nitrogen gatherer.—The peanut plant, in common with other leguminous plants, has the power of collecting the free nitrogen of the atmosphere and storing it in little nodules upon its roots. For this reason the peanut is one of the more desirable of our soil-renovating and soil-improving plants. It should be borne in mind, however, that in order to benefit the soil the nitrogen so gathered should not be removed, but that the main portion of the roots should be left in the soil. Figure 4 shows the root of a peanut plant which is abundantly covered with the nitrogen-storing nodules.

THE SEED AND ITS SELECTION.

Importance of planting good seed.—A good grade of seed is just as important with the peanut as with corn, wheat, or any other crop. There is perhaps no other farm crop except corn that is so greatly influenced by the character of seed planted as the peanut. The very best peanuts of the previous season's crop should be selected for seed, and of these only the most mature and perfect peas should be used. Seed should be saved only from well-ripened and mature plants and should be properly cured and kept dry during the winter months. Good seed produces a more even stand of plants, which in itself returns a greater yield.

Improvement by selection.—The seed should not only be selected from plants that are mature, but from those producing a large number of mature pods as well. By doubling the number of well-filled pods on each plant the yield for each acre will also be doubled. Many millions of bushels have been added to the corn crop of the country simply through the selection and improvement of seed.

What has been done with corn is possible with the peanut, and where we now have an average yield of 34 bushels to the acre it is reasonable to expect this to be increased to 50 or 60 bushels through seed and cultural improvements.

Planting shelled or whole seed.—In planting the large-pod varieties it is desirable for several reasons that the seed be shelled. In the first place, the planting machines now in general use are adapted to handling the shelled seed only. Second, when planting whole pods there is always a doubt regarding their being well filled, and a poor stand may result. Third, pods containing two or more seeds will produce more than one plant in a hill, causing a waste of seed and a crowding together of the plants. Fourth, whole seed is slower in germinating than shelled seed. With the Spanish variety the case

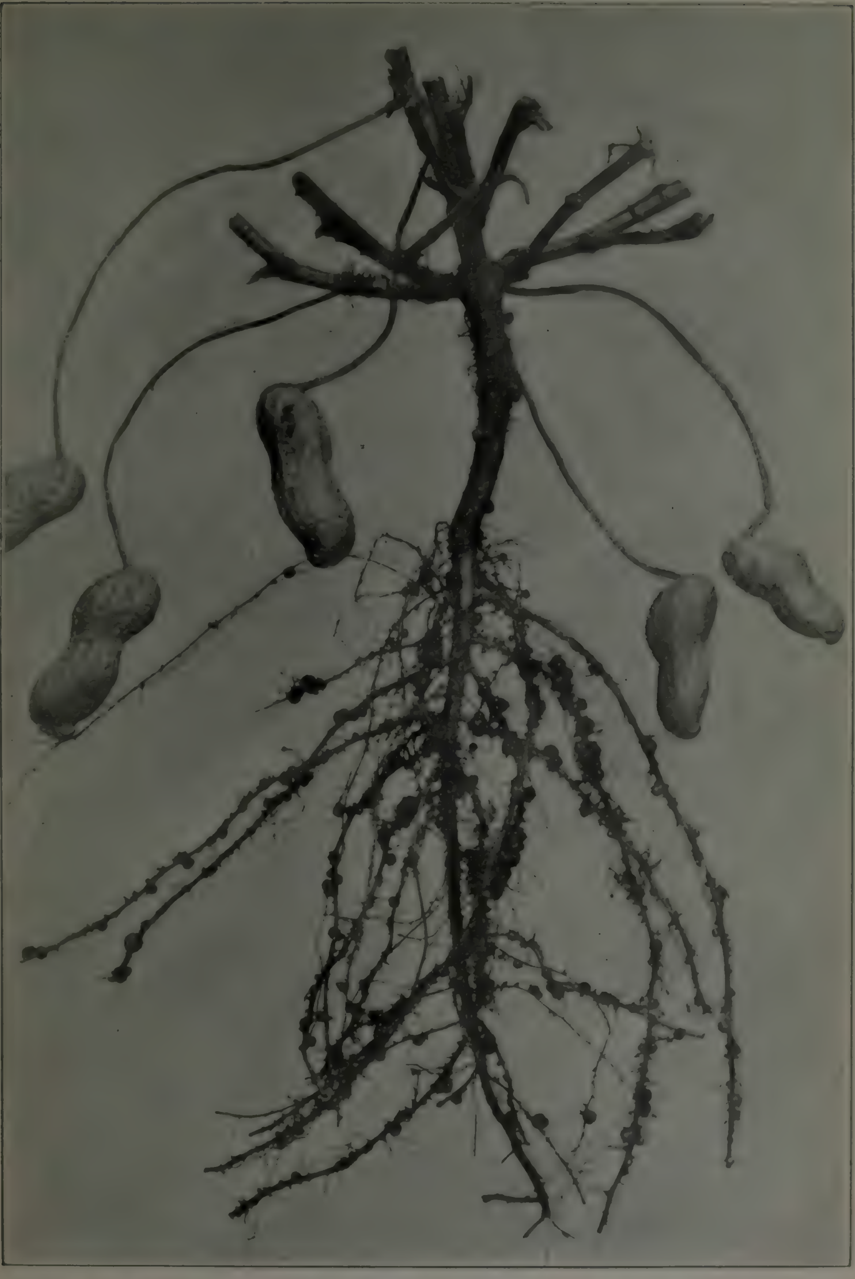

FIG. 4.—Roots of peanut vine, showing the value of this plant as a nitrogen gatherer. The nodules on the roots are formed by the bacteria which collect the nitrogen.

is quite different, as the pods are invariably filled, the crowding together of the plants is no great disadvantage, and the few days extra time required for germination is of little consequence.

Virginia nuts intended for seed should always be shelled by hand, but the Spanish are sometimes shelled by machinery, although their germination is invariably injured when so handled. Many growers of the Spanish peanut practice soaking the unshelled nuts in water previous to planting. Soaking for a few hours will hasten germination, but if for any reason the seed can not be planted immediately it will be lost. Shelled seed should never be soaked before planting.

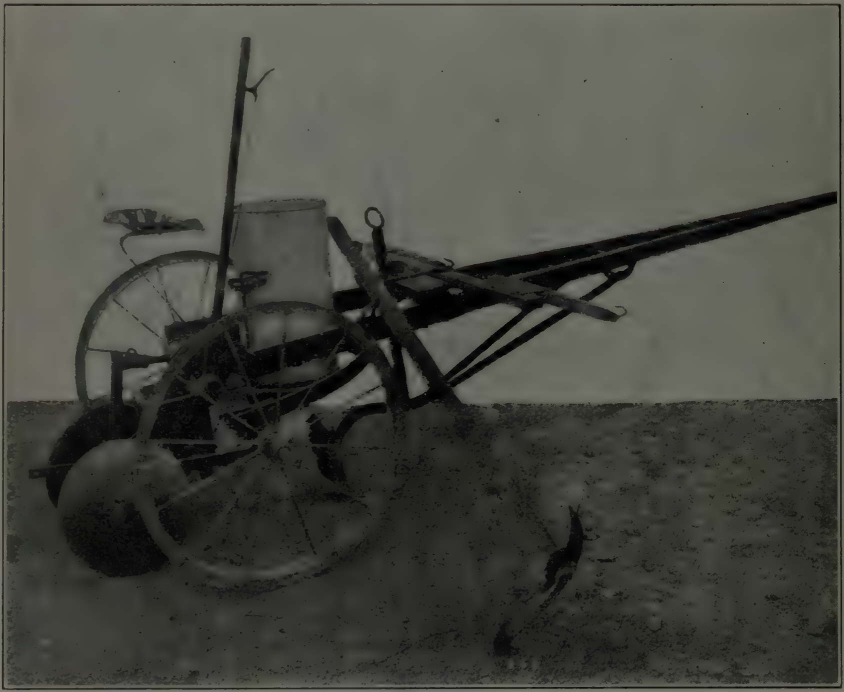

FIG. 5.—Machine for marking land and sowing fertilizer.

TIME AND METHODS OF PLANTING.

Time of planting.—The time for planting peanuts is in the spring after the soil has become thoroughly warm. In order to secure a good stand, the seed should not be put in the ground until there is sufficient warmth to germinate it quickly. As a rule peanuts should be planted a trifle later than corn and beans. The Spanish variety may be planted somewhat later than the Virginia type, as it requires less time to complete its growth.

As previously mentioned, the Spanish and similar varieties may in certain localities be planted after oats—that is, from the middle of June to the 10th of July. The Virginias or large sorts should, if possible, be planted before May 20 for the best results.

Distance to plant.—A common distance between rows is 36 inches, but this varies somewhat according to the soil and variety. For the Virgina Runner variety on good soil the distance between rows should be at least 36 inches, and 16 inches between the plants in the rows. Virginia Bunch peanuts may be in rows as close together as 30 inches, and 9 to 12 inches apart in the rows. The Spanish and Tennessee Red varieties are planted in rows from 28 to 36 inches apart and 9 to 12 inches apart in the rows, according to the fertility of the soil. On rich soils, where the spread of vine will be great, the maximum distance between rows as well as between plants in the row should be allowed.

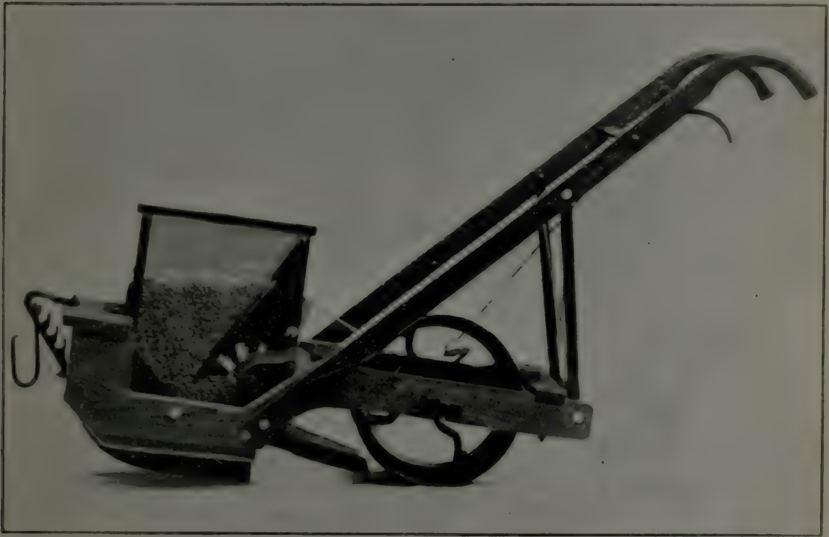

FIG. 6.—One-horse peanut planter.

Quantity of seed required.—The quantity of seed peanuts required to plant an acre will depend somewhat upon the distances of planting. As a rule 1½ pecks of shelled Virginia peas will plant an acre. One peck of shelled Spanish peanuts, or 1¼ bushels in the pods, are required for an acre. The greater the care exercised in planting, the smaller will be the waste of seed, and economy is quite an object when planting specially selected or high-priced seed. By planting the Spanish variety in the pod two seeds will be placed together in a hill, but there can be no very great objection to this, as the two plants will generally give a better yield than where the plants grow singly.

Depth to cover the seed.—The depth to which the seed should be covered will depend somewhat upon the character of the soil. On heavy soils three-fourths inch to 1¼ inches will be sufficient, while on light sandy soils 1½ to 2 inches may not be too deep.

Tools and methods of planting.—Peanuts are generally planted in rows that are cultivated in one direction only. Some growers follow the practice of first marking the land with an implement similar to the ordinary corn marker. Others open a furrow with a one-horse plow, then after the fertilizer has been distributed in the furrow the plow is again used and a slight ridge thrown up. There is now on the market a tool of the type shown in figure 5, which sows the fertilizer, throws up a slight ridge, and at the same time indicates the position of the next row.

The greater portion of the peanut crop is planted with the one-horse planters of the type shown in figure 6. These machines are similar in many respects to a cotton planter and cost about $15 in most localities.

Where the Spanish and similar varieties are planted in the shell the usual method is to open a small furrow, drop the seed by hand, then cover it by means of a small harrow or cultivator with a notched board fastened across the back of the implement. Doubtless, satisfactory machines for planting in the shell will shortly be upon the market.

GENERAL CULTIVATION.

Method of cultivation.—Cultivation of the peanut crop should begin immediately after planting and continue until the vines occupy the ground. The work of cultivation should be pursued very much the same as for corn, beans, and all similar crops. Frequent shallow cultivation that will keep the soil loose and prevent the loss of moisture is essential. Shortly after rains the surface soil should be stirred and during dry weather a dust mulch maintained. During the later cultivations it will be desirable to work the soil toward the rows to provide a bed of loose earth in which the pods may form.

After the peanuts begin to "peg," or form pods, they should not be disturbed or given further cultivation. The old idea that the blossoms of the peanut must be covered is erroneous, although growers frequently allow considerable soil to be thrown over the vines during the final cultivation. For the last cultivation it is a common practice to employ a tool that will both throw the soil toward the rows and leave a furrow in the middle of the alley to carry off water during heavy rains.

Common crab-grass is one of the most troublesome weeds of the peanut fields, and it is often necessary to resort to hand hoeing in order to keep this and other weeds out of the rows. If the crop is kept well worked with horse tools, very little hand labor will be required.

Tools adapted to cultivating peanuts.—Most implements that are adapted to the cultivation of corn or cotton will be found suitable for handling the peanut crop. For the first two or three cultivations a one-horse weeder of special type may be used crosswise of the rows. After the plants are tall enough so the rows can be followed, a spring-tooth riding cultivator is desirable, while for the later workings the same implement can be used by changing the spring teeth for regular cultivator shovels. For one-horse cultivation the ordinary cotton sweep is frequently used, but the form of cultivator shown in figure 7 will do more efficient work. This implement is provided with several styles of narrow and broad shovels, sweeps, and hillers, making it possible to adapt it to the requirements of a wide range of conditions.

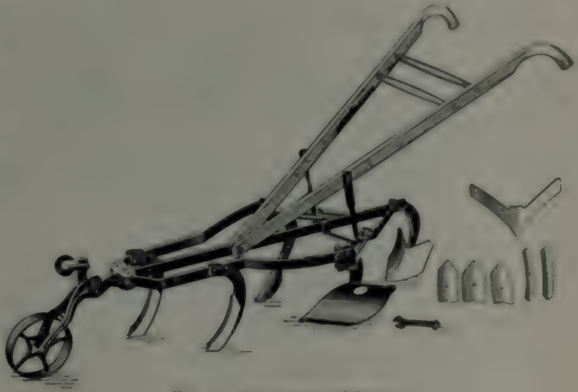

FIG. 7.—One-horse cultivator.

Some growers follow the practice of running a light roller over the plants after the final cultivation, the object being to flatten the stems upon the ground in order that the little pods forming on the extremities of the stems may reach the soil. This practice may increase the yield, but it will also increase the percentage of "saps," or unfilled pods, and it is doubtful if anything is gained by the practice.

HARVESTING.

Proper time for digging the crop.—No fixed rule can be given by which to determine when to remove the peanut crop from the ground, and each grower must be his own judge in the matter. In general practice the growers aim to dig before the first frosts, in order that the peanut vines may have greater value for stock food. To the southward, where frosts do not appear until quite late, the vines assume a yellowish appearance during the latter part of the season, which indicates the ripening of the peas. If digging is deferred too long, the first-formed peas are likely to burst their shells and start growing; this is especially true if there is a period of rainy weather late in the season. The aim should be to dig at the time the vines have upon them the greatest number of mature peas. Where a large acreage is grown it will be necessary to begin harvesting as soon as the earliest peas are ready, in order to complete the work before unfavorable weather sets in.

Methods employed for lifting the plants.—Under ordinary circumstances the peanut vines are plowed from the ground with a one-horse turning plow and afterwards separated from the soil by hand. Many growers employ either a two-horse plow similar to that frequently used for digging potatoes or a turning plow with the mold-board removed to prevent a furrow being turned. A digger of this type is shown in figure 8. Behind the digger or plow a gang of workmen shake the vines and peas free from the soil and throw them in small bunches. In this manner a team and driver accompanied by eight or ten hands will dig from 5 to 7 acres a day at a cost of about $2.50 an acre.

It has been found by experiment that the regular machine potato digger drawn by two or three horses driven by one man will dig from 8 to 12 acres a day and do the work in a much cleaner and better manner than the old plow and hand method. This machine not only removes the peanuts from the ground in a more perfect manner but also shakes off the soil, leaving the vines lying loosely upon the surface of the ground. By the hand method a few pods become detached from the vines, while with the machine potato digger scarcely a pod is lost. A machine of this character in operation is shown in figure 9. Another machine slightly different in design is shown in figure 10.

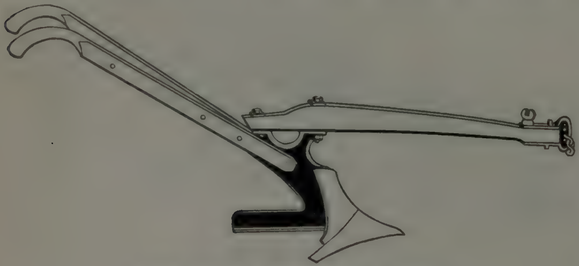
FIG. 8.—Plow type of peanut digger.

The cost of a machine potato digger is about $75, but with proper care it should last many years. Almost any of the machine potato diggers may be used for digging peanuts, but where the vines of the "runner" peas are exceptionally heavy there may be some difficulty in getting the vines through the machine. This difficulty may be overcome by providing disks or cutters to cut away the ends of the vines in front of the machine.

Special machines are now being offered which are intended to dig, clean, and bunch the peanuts. By setting any of these machines to the proper depth it is possible to sever the main root of the peanut just below where the pods are formed and thus leave considerable of the accumulated nitrogen in the soil. It is estimated that the nitrogen left in the soil by this system has a fertilizing value of from $3 to $8 an acre.

Several local devices have been constructed, usually upon the plan of an ordinary plow, but having a U-shaped blade or cutter with one edge sharpened and so mounted that it may run underneath the peanut plants. It is desirable to use a double team, straddling the row, so that the digger will run at a uniform depth. Almost any blacksmith can construct a tool of this kind and it should not cost more than $5 or $6. Any device that will sever the roots of the peanut just below where the peas are formed will answer the purpose and prove better adapted to the work than the plow. Past methods as practiced in Virginia, where the peanuts are removed by means of an ordinary plow, taking most of the nitrogen from the soil, are largely responsible for the rapid depletion of soil fertility in those lands.

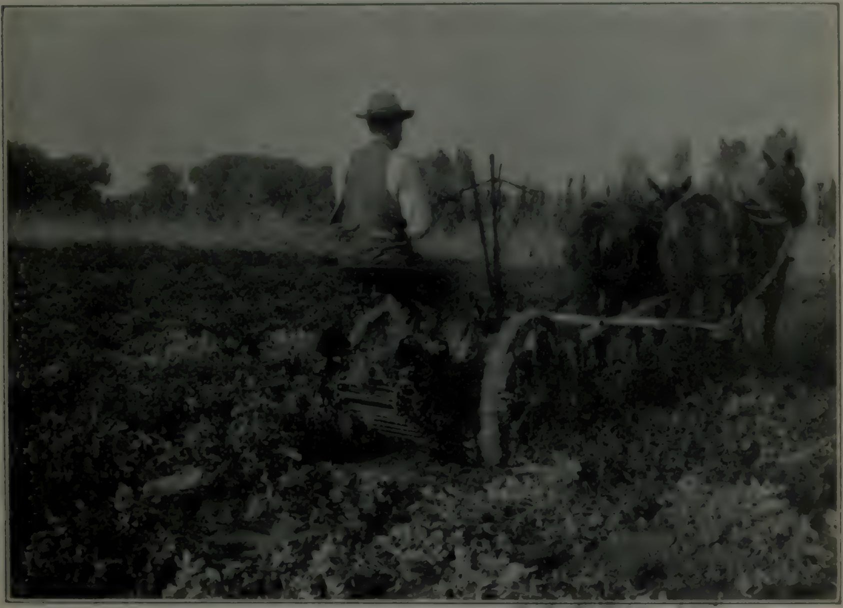

FIG. 9.—Machine potato digger in use in digging peanuts.

Curing process and care of crop after digging.—After the peanut vines are loosened from the soil they are allowed to lie either spread upon the ground or in small bunches for three or four hours, and are then placed in small stacks around a central stake to cure. If the peas are allowed to lie exposed to the weather for any length of time after digging, the pods become discolored and lose in weight.

A better grade of peanut hay will be secured if the vines are placed in the small stacks as soon as the leaves and stems are thoroughly free from dew or other surface moisture. Most growers follow the practice of putting the peas in stacks the same day they are removed from the soil, or those dug during the morning are stacked in the afternoon and those dug later in the day are stacked the following morning as soon as they are free from dew; however, any dew or rain will discolor the pods.

The essentials in caring for the crop during the curing period are that the peanuts be kept in small stacks, given an abundance of air, and protected from both the weather and injury from animals. Owing to the fleshy nature of the stems they cure quite slowly and are liable to mildew if placed in large lots.

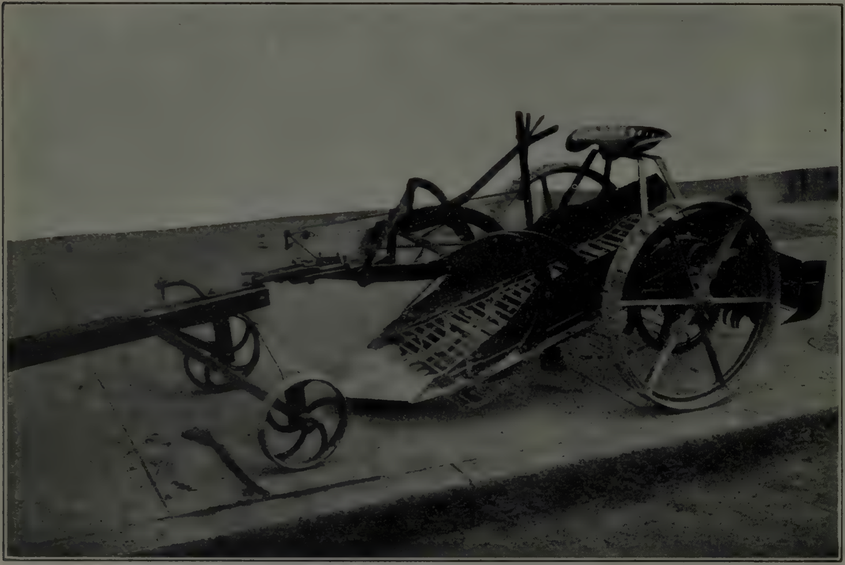

FIG. 10.—Machine potato digger adapted for harvesting peanuts.

The supply of stakes should be ready in advance and may be kept for use from year to year. These stakes should consist of split or round poles about 3 or 4 inches in diameter, 7 feet in length, and sharpened at both ends. For setting the stakes in the ground a pointed bar of iron or a crowbar with which to make the holes is necessary. The stakes should be set in the ground to a depth of 12 to 14 inches and well tamped to make them firm and solid.

Before starting the stack one or two pieces of lath about 18 inches in length are nailed at right angles to the stake 8 inches from the ground, in order to prevent the peanuts coming in direct contact with the soil. In starting to build the stack a few vines are laid across the pieces of lath and the stack then built up by successive layers of vines, the pods being kept well to the center against the stake and the tops to the outside. The stems should have sufficient outward slope to shed water. Occasionally a few vines should be hung around the stake in order to tie the stack together. By this method the pods will be near the center and around the stake, where there is an upward circulation of air and general protection. When the stack has reached the desired height, a bunch of vines is rolled together and pressed down over the point of the stake to form a top, or a little dry grass or weeds may be used for this purpose.

It is not advisable to use anything for topping out the small stacks that will prevent the circulation of air. A heavy cover or a covering of green or wet hay will invariably cause the peanuts to spoil.

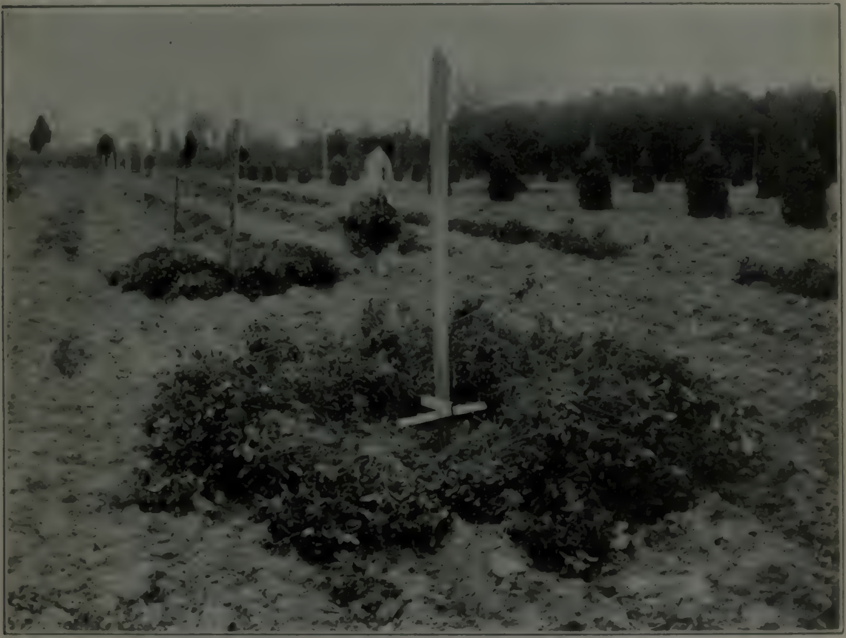

FIG. 11.—Stakes around which stacks of peanut vines are to be built.

The majority of growers follow the practice of placing the stacks singly in rows in the field where the crop is grown; others arrange them in groups of from four to ten, while some growers haul the crop to a stacking yard, where the stacks are built closely together. Figure 11 shows stakes set in the ground and crosspieces nailed on. Figure 12 shows a stack during construction, as well as completed stacks in the background. Figure 13 shows the method of stacking closely together.

Storage in barns is not advisable, either when curing peanuts for market or where the entire plant is fed to stock, as the crop may be handled more economically and a better grade of hay produced by putting it up in the small stacks. After the peanuts have cured in the stacks from four to six weeks, those intended for feeding to stock may be placed in barns.

PICKING AND CLEANING.

Time of picking.—Peanuts for market should be cured in the stack at least three or four weeks before picking. If the weather is dry and windy immediately after harvesting, the curing process will be quite rapid, but should the weather conditions be unfavorable during this period the pods will ripen more slowly. Too rapid curing is not desirable, as the pods are likely to shrivel and discolor. Peanuts should not be picked from the vines until the pods have become dry and the peas firm and nutty, with the immature ones more or less shrunken. As a rule very little is to be gained by early marketing, and a better grade of peanuts will be secured if picking is deferred until late autumn. If the pods are not well protected in stacking, many will be destroyed by the common crow. In some sections it is necessary to pick as early as possible to prevent heavy loss from the ravages of field mice and rats while the peanuts are in the stack.

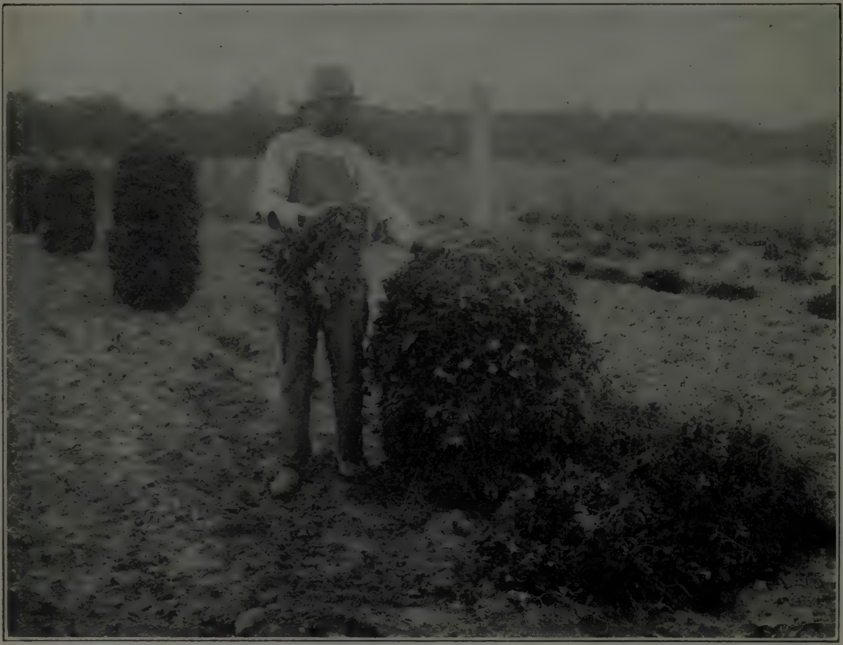

FIG. 12.—Laborer building a stack of peanut vines, showing method used. Completed stacks in background.

If peanuts are not well stacked the pods are liable to become discolored by the heavy fogs and driving rains of late autumn. The stacks should not be opened nor the vines handled during wet weather.

Picking by hand.—The standard of excellence in the peanut markets is always based upon hand-picked stock, but with the present scarcity of labor and rapid improvement in peanut-picking machinery the time has come when a uniform price is paid for a given quality of peas regardless of how the picking is done.

Figure 14 shows a characteristic group of pickers at work in a peanut field of southern Virginia. Hand picking is at best a dusty and laborious task and is usually done by the women and children.

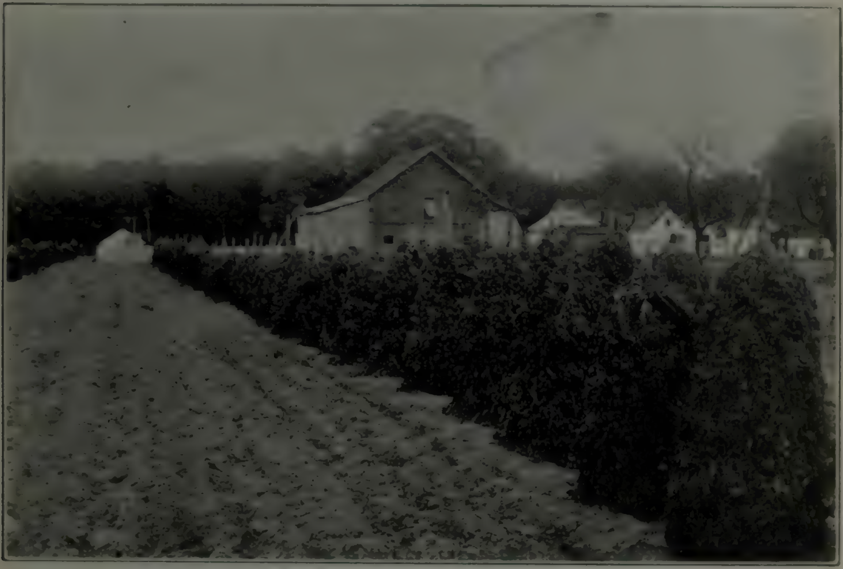

FIG. 13.—Peanut stacks placed close together near farmyard.

Where the vines are well set with pods a good picker will handle from 8 to 12 bushels a day. The price paid per bushel for picking varies from 8 to 20 cents, according to the quality and variety of peanut, but 10 cents is the ruling price paid for picking Virginias. In some localities the pickers are paid by the hundred pounds, 40 cents a hundred being the average price paid. At this rate the cost of picking the peanuts grown on one acre will vary from $4 to $8.

Use of machines for picking.—Two types of machine are employed for picking peanuts from the vines. A cylinder machine similar to a regular grain separator except as to size has been used for several years, especially in the districts where the Spanish variety is extensively grown. The principal objection to all the cylinder machines is the tendency to break the pods and both shell and injure the peas. By running the cylinder quite slowly, say at 400 revolutions a minute, and feeding properly it is possible to thrash peanuts by using a cylinder machine with a very small percentage of loss from breakage. Pods that are merely cracked or that have what the growers term "oyster mouths" will not keep for a long period but become rancid or are injured by small insects while in storage.

There are machines in use which work upon an entirely different principle from the cylinder machines and which do not break or injure the pods. In these machines the picking is done by dragging the vines over a horizontal wire mesh, and at the same time brushes act on the lower side of the wire screen to remove the nuts. Very little power is required to operate these machines, two complete outfits being run at once by an 8-horsepower gasoline engine. The capacity of these machines is from 250 to 500 bushels a day. In addition to removing the pods from the vines the machine has the usual cleaning arrangements and a device for removing the small stems from the pods, delivering them in a condition suitable for the cleaning factory. Figure 15 shows one of these machines in operation.

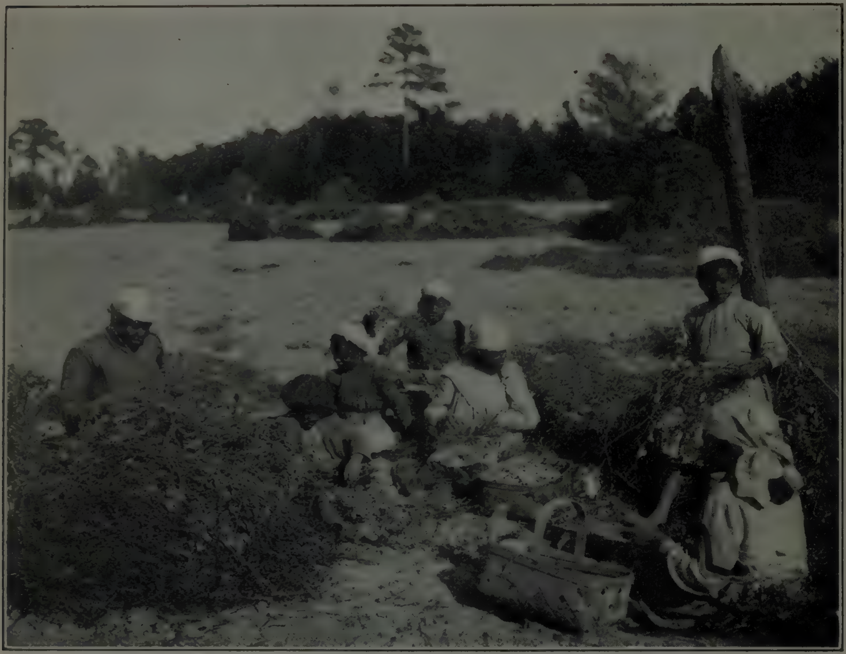

FIG. 14.—Picking peanuts from the vines by hand.

Care of peanuts after picking.—At no time after the curing process should the peanut pods be exposed to water, or even dampness, as the shells invariably become darkened and discolored by the addition of moisture. When properly cured the shells will be covered with a fine, dry dust, and where this dust becomes moistened it adheres and forms a brownish spot. If the peanuts show the least trace of dampness after their removal from the vines, they should be spread on a floor or stored in a well-ventilated building until thoroughly dry. Many of the larger growers have provided narrow cribs similar to those employed for the storage of corn, and the peanuts are kept in bulk until sold. When the pods are thoroughly dry they may be put into bags as they come from the machine, and either hauled direct to the cleaning factory or stored in small lots.

Preparation of peanuts for market.—As the peanuts come from the hands of the pickers or the thrasher they contain considerable rubbish and have more or less soil adhering to the pods. The extent to which the pods must be cleaned and graded will depend upon the use to which they are to be put; if for vending purposes they will require a factory process, but if for shelled nuts very little work will be necessary to prepare them for the sheller. Under the present status and extent of the peanut industry the cleaning factory has become an important factor, and the interests of the grower and cleaner are correlative and should be cooperative. Where Spanish peanuts are grown on an extensive scale it may be feasible for the farmer to own and operate a small shelling and cleaning outfit. In the case of the large-podded varieties several grades are made from one class of stock, requiring an extensive, although simple, equipment and the handling of large quantities of nuts in order to make the enterprise profitable.

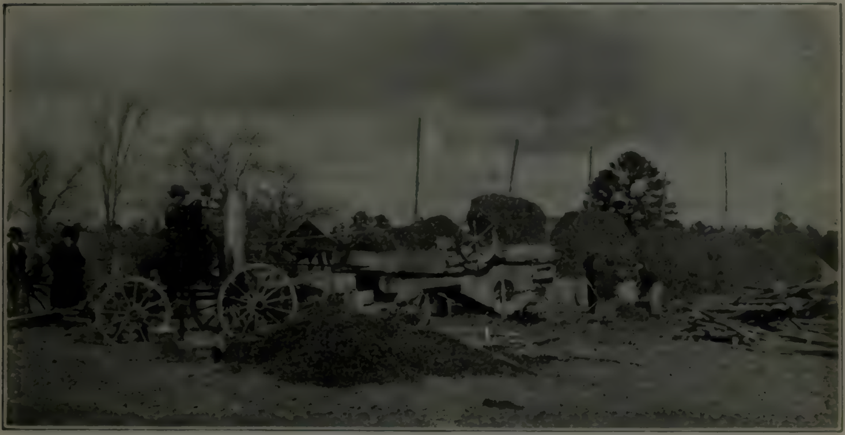

FIG. 15.—An improved type of peanut-picking machine in operation.

Methods of cleaning peanuts in the factory.—The cleaning or factory process consists chiefly in the removal of all dirt and the separating of the nuts into their respective grades. In addition to grading, the higher class product is treated to a polishing process, which gives the pods a more attractive appearance when exposed for sale. The modern peanut-cleaning factory consists of a four or five story building, which is supplied with power, lighted by electricity, and provided with elevators and bins for handling and storing the unclean nuts. It also has a full equipment of fans, grading machines, polishing drums, and shellers, and an abundance of lower-floor space for the storage of the bags of nuts that are ready for marketing.

When the peanuts are received from the farmer at the factory they are weighed and then elevated to the top floor of the factory. During the cleaning and grading process they descend by gravitation through the fans and graders, are tumbled in the polishing drums together with a small quantity of marble dust to whiten and polish the pods, are passed on slowly moving belts between lines of women who are expert in detecting foreign matter and inferior nuts, and finally drop into bags on the lower floor.

In the modern cleaning factory all dust and refuse is removed by means of fans and ventilators, the portions of sticks, stems, and broken shells being conveyed to the boiler room and fed into the furnace. One advantage of a factory process is that nothing need be wasted, as all broken or split peas can be worked into the stock used in the manufacture of peanut products.

Cleaned vines as stock feed.—The peanut vine or straw from which the nuts have been removed is of considerable value for feeding purposes, being about equal to clover hay. Where the peanuts are picked from the vines by hand the stems become broken and the greater portion of the leaves is lost, but where machines are used for picking it is possible to save the straw in fairly good shape. If the vines are bright and clean after the pods have been removed they can either be sold or fed to farm animals, and they will in this way partly pay for the cost of planting and cultivating the crop. Some growers employ a baling press and bale the straw as it comes from the thrasher in order that it may be more easily stored and also be available for marketing.

VARIETIES OF PEANUTS.

CLASSIFICATION OF TYPES.

Not more than five or six distinct varieties of the peanut are grown in the United States, but these few varieties represent at least three separate types. By classifying the varieties of peanuts according to types we have the large-podded, or Jumbo, peas and the

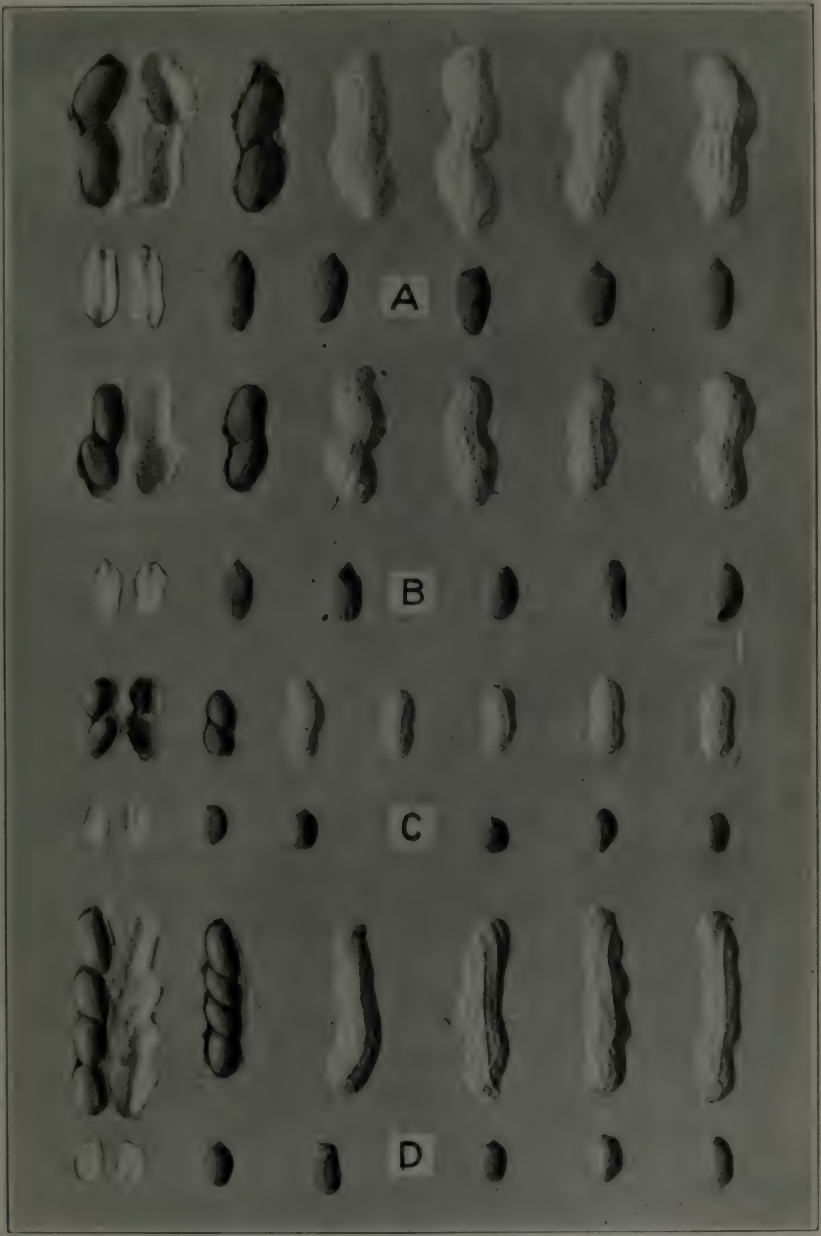

FIG. 16.—Commercial types of peanuts. A, Virginia Bunch, or Virginia Runner; B, African, or North Carolina; C, Spanish; D, Tennessee Red. (About one-half natural size.)

Spanish and African, both small-podded peas. These types are subdivided into bunch and runner peas. Figure 16 shows pods and peas of the more important commercial varieties.

Those varieties having a bunch habit of growth are most generally grown, owing to the fact that they may be planted closer together than the runner varieties. The bunch varieties are also more easily cultivated and harvested than the runner varieties.

DESCRIPTIONS OF VARIETIES.

The following descriptions of the more common varieties of the peanut may be of interest to those not already familiar with them:

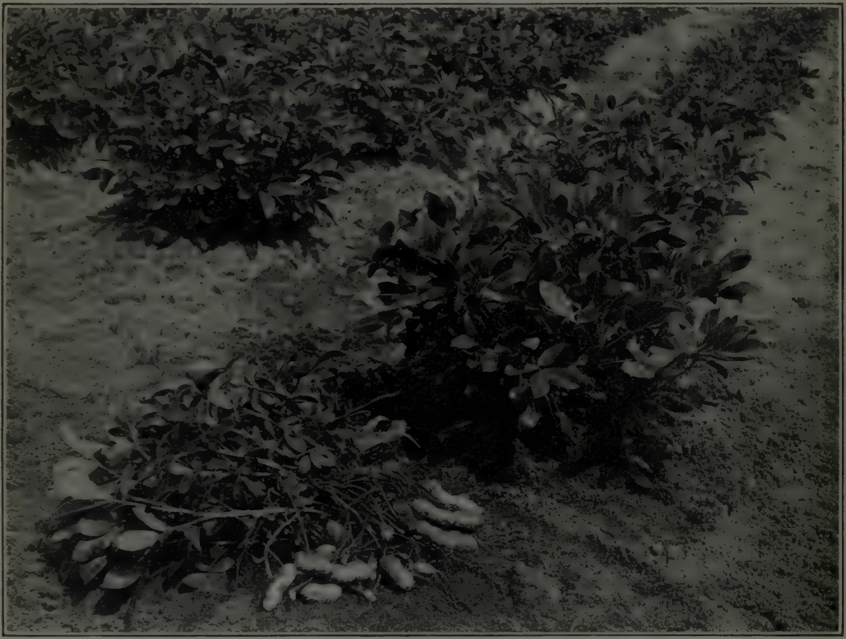

FIG. 17.—Virginia Bunch type of peanut.

Virginia Bunch.—Large-podded variety, plant rather dwarf, stems upright, foliage rather light; pods clustered about the base of plant; usually two, sometimes three, seeds in a pod, pod bright and clean, color of peas light brown; pods adhere well to plant in digging. The customary weight per bushel of this variety is 22 pounds. (Fig. 17, and fig. 16, *A*.)

Virginia Runner.—Large-podded variety, strong grower, stems creeping, foliage heavy; pods scattered along procumbent stems; pods and peas very similar to those of the Virginia Bunch; pods do not adhere well in digging. The customary weight per bushel of this variety is 22 pounds.

Spanish.—Small-podded variety, strong grower, stems upright, foliage abundant and heavy; pods clustered about base of plant, usually two seeds in a pod, entirely filling the pod; color of peas light brown; pods adhere well to plant in digging. This variety frequently yields 60 bushels of marketable peas and a ton of hay to the acre. The peas of this variety are rich in oil content. The weight per bushel of Spanish peanuts is 30 pounds. (Fig. 18; and fig. 16, *C*.)

Tennessee Red.—Small-podded variety; similar to Spanish, except that the pods are longer, sometimes containing five or six peas crowded together; peas dull red in color. This variety is well adapted to stock feeding, but does not sell upon the market owing to the color and quality of the peas. (Fig. 16, *D*.)

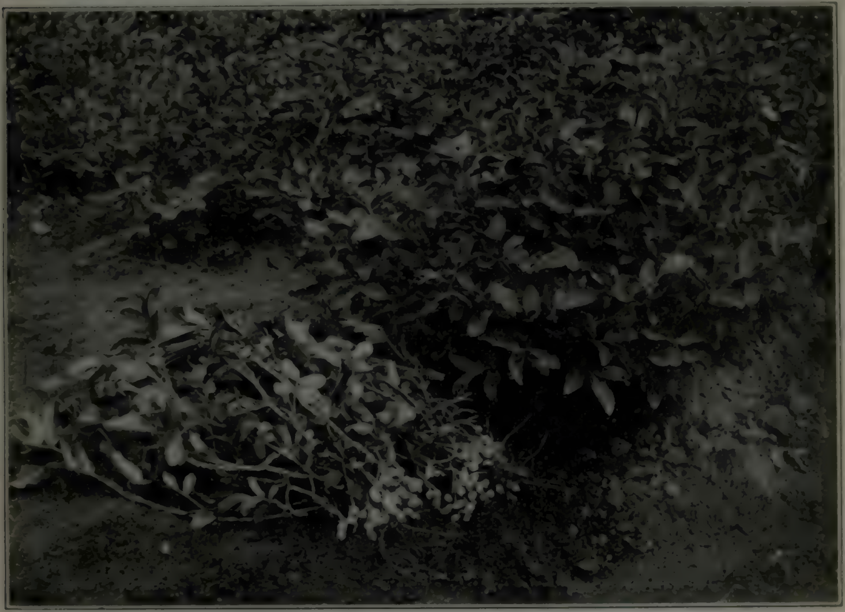

FIG. 18.—Spanish type of peanut.

Valencia.—A very promising new variety introduced from Spain. Similar in many respects to the Tennessee Red, but of much better quality. A desirable sort for the manufacture of peanut butter, also blanched and salted peanuts. A heavy yielder and matures in about 120 days.

African, or North Carolina.—A variety that is much grown in Africa for oil production. A very rank grower, the stems spreading over the ground. Foliage dark green and massive. Pods form along the stems similar to the Virginia Runner. The pod is of medium size and generally contains two peas, sometimes three. Rich in oil and of excellent flavor. This variety requires a long season for its development and should be planted quite early. (Fig. 16, *B*.)

VARIETIES FOR MARKETING.

For vending purposes, where the peas are roasted and sold from the fruit stands, the large-podded varieties, including Virginia Bunch and Virginia Runner, are in greatest demand, although considerable quantities of Spanish and North Carolina are used for this purpose. For shelled peas the smaller nuts of the large-podded stock are employed; also the greater part of the crop of Spanish, North Carolina, and Tennessee Red varieties. A large percentage of the shelled stock is of the Spanish variety.

VARIETIES FOR STOCK FEEDING.

When peanuts are grown exclusively for feeding purposes the Spanish is undoubtedly to be preferred. If it is desired to market the high-grade portion of the crop and feed the remainder, the question of variety to be grown will depend largely upon locality. Many growers throughout the peanut area follow the practice of planting several acres of Spanish peanuts and disposing of all of the better-grade peas to some factory for shelling purposes, the vines and poorly filled pods being fed to farm animals. The Spanish peanut can be grown under a much broader range of conditions than the large-podded sorts and should be employed where the season is short.

This variety also produces a heavy yield of vine and is desirable for forage purposes. The Valencia is very similar to the Spanish variety in habit of growth, is desirable for stock feeding, and is rapidly finding a place in all branches of the market with the exception of the retail trade in roasted peanuts.

THE USES OF THE PEANUT.

To most persons the peanut suggests only the article as it appears for sale whole or shelled and salted, but during recent years the uses of peanuts have become numerous, and include a wide range of utility. The demand for peanuts for use in the manufacture of food preparations is constantly increasing. By-products of the peanut are now being employed extensively in the manufacture of feeds for farm stock and dairy cows, and the plant is being largely utilized as forage and as a soil renovator.

Important uses for human food.—Among the more important uses of the peanut for human food are the following: It is eaten from the shell, as salted shelled peas, as blanched peas, in the so-called peanut candies and brittle, in combination with pop corn and puffed rice, in the form of peanut butter, and as an ingredient of peanut and vegetable meats, peanut meal, and salad oils.

The use of the peanut for eating from the shell when roasted is most important and popular, but the quantity of shelled peas that are first roasted and then salted and sold by the pound is constantly increasing.

Comparatively small quantities of the better grades of peanuts are first shelled and then roasted and the thin brown covering removed, after which the halves of the peas are broken apart and the small germ removed, giving the meats a blanched appearance which renders them very desirable for table use.

Great quantities of shelled peas are used every year in the manufacture of peanut candies and brittle, both alone and in combination with other nuts, pop corn, or puffed rice. A very desirable kind of peanut candy can be made by simply boiling shelled peanuts with a thick sirup consisting of 2 pounds of granulated sugar and one large cupful of water, together with a teaspoonful of lemon juice. When the sirup begins to boil add 2 pounds of unroasted shelled peas and cook slowly until the peas are tender and the sirup sufficiently hard to break when quite cold. The cooking process should as a rule continue for about an hour, when the mixture should be poured on a cold buttered platter to cool. Peanut candies as a rule are not adapted to handling in warm weather and should be kept cold after making.

During recent years great quantities of shelled peanuts, especially of the Spanish variety, have been employed for the manufacture of peanut butter. This butter is prepared by the ton in factories, is put up in bottles or tins containing from one-fourth pound to 5 pounds each, and has become very popular as a part of the luncheon menu and for camping and cruising supplies. In the process of the manufacture of peanut butter the peas are first given a medium roast, care being taken that the meats do not become overdone or scorched. The peas are then fanned and screened to remove the thin brown coverings and the germs, after which they are ground to a pulp by means of a special grinder similar to those used for chopping meats. As the peanut pulp comes from the grinder it is fed through a tin tube into the bottles or tins and tightly sealed. Some manufacturers follow the practice of salting the peanut butter, while others leave this part of the process for the consumer, who can easily salt to suit the taste.

By a little experience and the aid of a small meat grinder, any one can make good peanut butter for home use. The peanuts may be roasted before or after shelling, but in either case the oven should be only moderately hot and the peas should be stirred frequently. After roasting, rub off the skins and screen out the small germs, or hearts. In grinding use the finest plate on the grinder and screw up the tension until the crank will be quite hard to turn. If the pulp is too coarse after one grinding it may be run through a second time. It will not be necessary to add anything but a little salt to the butter, but if desired the butter may be thinned by the addition of a little olive or peanut oil.

In the preparation of vegetarian meats a portion of the oil is expressed from the ground peanuts, other ingredients, including various vegetable substances, are added, and the whole is crushed and pressed into tins ready for use. In this case the extra oil is either used for thinning peanut butter or sold as a compound for use in further cooking the vegetable meats.

Peanut meal, made from finely ground blanched peanut meats, is used to some extent in confections. This meal is especially desirable in the manufacture of almond macaroons and small cakes, to which it imparts the desired almond flavor. It is also used in the manufacture of candies.

Peanut oil is used in the same manner as olive oil; also for mixing with cottonseed oil in order to improve the quality of the cottonseed oil for salad purposes.

The uses of peanut by-products as foods for live stock.—In the factories where peanuts are cleaned, shelled, and graded ready for the market there is always a certain percentage of cleanings and inferior stock that can readily be turned into stock foods. The outside shell, or hull, of the peanut is rich in food materials, but is extremely difficult to reduce to a condition in which it can be fed. In large cleaning factories the shells are generally used as fuel, and the ash resulting therefrom is valuable as a fertilizer, often containing as high as 3 per cent of phosphoric acid, 9 per cent of potash, and 6 per cent of lime.

The thin brown covering of the peas has a feeding value almost equal to that of wheat bran. These hulls are especially desirable for mixing with the smaller particles of broken peas for stock feeding. In large factories where peanuts are prepared for the manufacture of peanut butter and similar preparations the waste in the form of small particles of the meats and the germs is considerable and this is sold to farmers for feeding purposes. In some cases the waste is mixed with a portion of the hulls and finely ground or chopped before leaving the factory. Peanut hulls make an excellent bedding for use in stables, and by using them in this manner and hauling the manure upon the land their full value can be obtained.

Broken peas and germs are used largely as a food for hogs, but both should be fed in moderation and in combination with some grain, as the peanut fed by itself will produce a hog having soft fat and inferior meat. The famous Smithfield hams and bacon come from hogs that are fed partly on peanuts, the practice being to turn the hogs into the peanut fields after the crop has been gathered and allow them to glean the pods that were lost in harvesting. The principal objection to the use of peanut by-products as stock feed is their tendency to become rancid very quickly. The germs, which are high in nitrogen content, become rancid and bitter in a short while and should not be kept on hand for a greater period than fifty or sixty days.

Possibilities in the manufacture of peanut oil.—The oil of the peanut belongs commercially in the same class as cottonseed and olive oils. Peanut oil is of a higher grade than cottonseed oil and of somewhat lower value than first-class olive oil. Peanut oil is sometimes used for mixing with olive oil for the production of an oil that can be sold at a lower price than pure olive oil. On the other hand, peanut oil is frequently mixed with cottonseed oil in order to improve the quality of the cottonseed oil for certain purposes.

The quantity of oil that may be obtained from the peanut will depend upon the variety, the maturity of the peas, and the apparatus with which the extraction is made. The Spanish meats when shelled and thoroughly cleaned frequently contain as high as 45 per cent of oil, as shown by chemical analysis, although not more than 34 per cent can be expressed by the best of present methods and perhaps about 28 per cent by ordinary machinery. It is generally conceded that in order to make the manufacture of oil profitable good peanuts must be obtainable at prices not exceeding 75 cents a bushel. A bushel of first-class Spanish peanuts, weighing 30 pounds, will produce about 1 gallon of oil, worth 75 cents, and 20 pounds of oil cake and hulls, which when ground and mixed together will be worth approximately 25 cents, or $25 a ton, as stock feed.

The greater portion of the peanut oil of commerce is manufactured at Marseille, France, from peanuts that are bought very cheaply along the coast regions of Africa and transported by ships as return cargo. The African-grown peanuts are very rich in oil, often containing as high as 50 per cent. With a coming shortage of cottonseed from which to manufacture oil in this country there is a great possibility of building up a peanut-oil industry throughout the cotton belt of the Southern States. As already mentioned, there are thousands of acres of land now lying idle that will produce fairly good crops of peanuts, and their growth will improve the land. By combining the use of cottonseed and peanuts for the production of oil it would be possible to keep the existing oil mills of the South running at a profit to both the farmer and mill owners. The oil that remains in the cake will not be lost, as there is demand for the cake for fertilizers and for stock feed.

The process of expression is very similar to that for cottonseed oil and the greater portion of the machinery of the present oil mills is adapted to the manufacture of peanut oil.

USE OF THE PEANUT ON THE FARM.

Growing importance.—In sections where the soil and climate are suitable the peanut is rapidly becoming a crop of general farm importance. In the Southern States peanuts can be grown under a wide range of conditions, and the product can be used for several purposes. Peanuts are valuable as a substitute for cowpeas, especially on certain soils that are not adapted to the growing of the cowpea. In many sections where the clovers and other soil-renovating crops will not withstand the heat and drought of the summer months the peanut will thrive and make an excellent growth. A crop of peanuts for forage can often be grown after the removal of oats or some other spring crop, and although they may be badly overgrown by crab-grass, the tops may be mown with the grass for hay, and the hogs turned in to root out the peas.

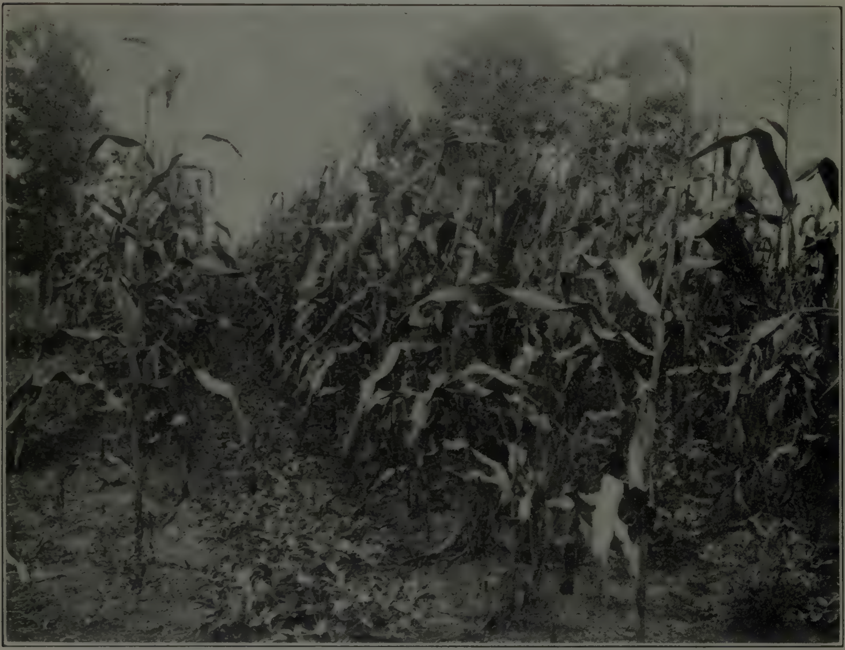

FIG. 19.—Peanuts growing in the alleys between rows of corn.

Throughout Georgia and the surrounding Gulf Coast States the peanut is extensively used for planting in the alleys between the rows of corn. The peanuts are planted at the time the corn is given the last working, and are allowed to grow as a catch crop among the corn. (Fig. 19.) After the corn is pulled, cattle are turned in to eat the fodder and the peanut tops. Following the cattle the land is pastured by hogs to clean up everything that remains. In this way most of the nitrogen stored by the peanut roots is left in the soil.

The value of peanut hay for feeding purposes.—The tops of the peanut plant when cut and cured in the same manner as other legumes will produce a hay that is almost equal in feeding value to the best clover hay. By planting the Spanish peanut in rows from 24 to 30 inches apart and quite closely in the row and by giving the crop about two cultivations, it is possible to produce from one to two tons of hay to the acre. After the hay is removed the pods can be turned out by means of a plow, cured, and stored for winter feeding, or hogs may be turned in to gather the crop. The following table shows the comparative value of peanut hay:

TABLE I.—*Comparative analysis of peanut hay and other hays.*

Dry matter.	Protein.	Carbohydrates.	Fats.
	Per cent.	*Per cent.*	*Per cent.*
Peanut hay	11.75	46.95	1.84
Peanut, entire plant	13.48	36.28	15.06
Clover hay	12.84	48.31	2.11
Timothy hay	7.17	52.94	1.97
Cowpea hay	19.72	45.15	4.04
Alfalfa hay	16.48	42.62	2.03

Peanut straw, consisting of the entire vine after the salable nuts have been removed, has a somewhat higher feeding value than the tops alone, due to the fact that many of the inferior pods are left in the straw. Peanut straw is, however, not so bright or palatable for feeding as are the peanut tops when cut and cured especially for hay.

The value of the entire peanut plant as forage.—Throughout that portion of the Southern States where field corn does not yield a satisfactory crop, the place of corn for feeding to animals may be largely taken by the peanut. On some ranches where a large number of work animals are maintained the Spanish peanut, including the entire plant, is practically the only feed used.

The peanut vines and peas when chopped or ground together form almost a balanced ration for a dairy cow. The following table will give some idea of the comparative value of peanut products and other feeding stuffs:

TABLE II.—*Comparative analysis of peanuts and other feeding materials.*

Dry matter.	Protein.	Carbohydrates.	Fats.
	Per cent.	*Per cent.*	*Per cent.*
Ground corn and oats	9.6	71.9	4.4
Corn meal	9.2	68.7	3.8
Wheat bran	15.4	60.4	4.0
Cottonseed meal	42.3	23.6	13.1
Peanut kernels	26.6	16.7	42.0
Peanut vines	10.0	42.0	3.6
Clover hay	12.4	33.8	4.5
Alfalfa	14.3	42.7	2.2
Peanut, whole plant	13.5	36.2	15.0

The use of peanuts for fattening hogs.—As already suggested, the peanut is a valuable feed for use in preparing hogs for market, the usual custom being to turn the hogs into the peanut fields and allow them to glean whatever is left after harvesting. In some sections peanuts are being grown primarily for feeding to hogs. Poorly filled nuts, broken peas, the germs, and waste products generally are fed to hogs during the earlier part of the fattening period. A hog that is fattened exlusively on peanuts will not yield a desirable grade of meat or lard, as the meat will lack firmness and the lard be soft and oily. Toward the end of the fattening period the hog should be fed almost exclusively on corn. Hogs will eat considerable of the peanut tops when pastured on them, and the plan of dividing the field into small areas by portable fences and allowing the hogs to gather the peas is perhaps the most economical.

A method that has been found very satisfactory is first to cut the peanut tops for hay, then turn in hogs. By turning the hogs into the field for a short time only each day, the injury to the soil will not be so great as if they were left in continuously.

Methods of handling and curing peanuts for forage.—Where the entire peanut plant is to be stored and used for feeding to stock the work of curing and caring for the vines should be very much the same as for market purposes, although the crop may be handled very much in the same manner as cowpeas. By experience it has been found most economical to harvest and stack the peanuts in exactly the same manner as already described for market purposes; however, the stacking may or may not be done so carefully.

Peanut vines if handled in the same way as vines of the cowpea yield a very desirable class of forage. Persons who have used the peanut exclusively for feeding purposes claim that they have had no difficulty in feeding it to all kinds of work animals, even driving horses. It is well, however, to feed only a part ration of peanut vines at first and to observe the animals until they become accustomed to this form of diet. Under ordinary circumstances the plant is fed without removing the nuts, but it may be well in some cases to pick the peanuts from the vines and grind them, shell and all, and then feed as a meal with the vines.

INSECTS INJURIOUS TO THE PEANUT.

The insect enemies of the growing peanut crop have been so few that very little attention has been given them by entomologists. Recently a species of aphis has been reported as working upon the roots of the peanut plants. This insect belongs to a class that obtains its food by sucking the juices of the plant from beneath the surface of the leaves, stems, or roots. The presence of this root aphis is indicated by patches of what appears to be a white mold upon the roots and pods of the peanut and is generally not observed until digging time. Thus far no great injury from these insects is apparent, but should they become very numerous great damage will ensue, and about the only satisfactory remedy which the writer can suggest is crop rotation, planting peanuts on clean land each year, and only returning to the original piece after a period of four or five years.

While in storage peanuts are attacked by various insects. So long as the shells remain unbroken these insects can not gain access to the meats, but where the shells have been injured or broken in thrashing or in subsequent handling the peas can not be kept during the summer months. These insects are especially destructive in storage houses and cleaning factories where peanuts are held for summer trade. They may be destroyed by fumigation with carbon bisulphid in the factory or warehouse. Carbon bisulphid forms an inflammable gas, and its use is attended with some danger and should be applied by an experienced person.[a]

DISEASES OF THE PEANUT.

The peanut crop has thus far been remarkably free from disease. About the only disease that has been at all prominent is a form of leaf-spot (*Cercospora personata* (B. & C.) E. & E.) which appears in the form of small brown spots on the leaves. (Fig. 20.)

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[a] For information regarding the use of this insecticide the reader is referred to Farmers' Bulletin 145, which may be obtained upon application to the Secretary of Agriculture. No general work has been published by this Department on the insect enemies of peanuts, but information in regard to any of them may be obtained by application to the Bureau of Entomology. Correspondence will be facilitated if specimens of the insects concerned in the damage accompany letters of inquiry.

This disease is especially noticeable on the young plants during a wet spring, giving the leaves the appearance of having been scalded by the sun. Later in the season the plants will as a rule outgrow the disease, except in low or poorly drained portions of the fields. Where the disease is abundant upon the foliage the pods are frequently discolored and rusty. There can be no doubt that this disease causes considerable reduction in yield on land that is sour or poorly drained. It is often observed that the disease will be abundant in low spots without spreading to other parts of the field. The presence of the disease upon the foliage of the peanut greatly decreases the value of the vines for hay. Should this trouble become prevalent it may be controlled by spraying with Bordeaux mixture. Its development may be prevented by proper drainage.

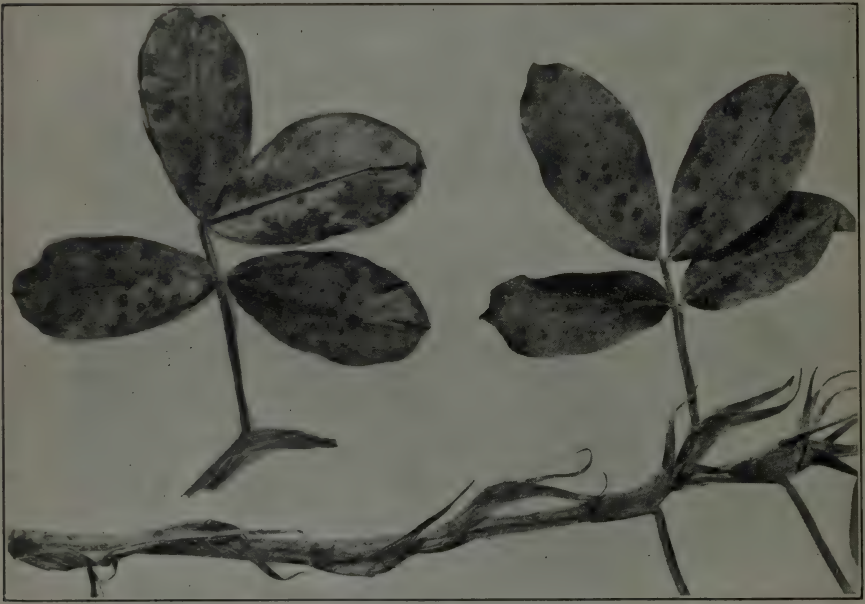

FIG. 20.—Disease appearing upon the leaves of the peanut.

CONCLUSIONS.

The peanut is worthy of more general cultivation throughout the Southern States, especially in the boll-weevil district, where it will in many cases be found more profitable than cotton.

The uses of peanuts as a general farm crop throughout the Southern States are becoming more numerous, especially as a means of providing suitable forage for range stock during the short winter period.

The demand for peanuts to be used in the preparation of human foods is constantly increasing.

The United States is a heavy buyer of peanut oil that is produced abroad, while there are thousands of acres of waste lands in the Southern States that would produce enough peanuts to keep the cottonseed-oil mills running and furnish more than enough oil for home consumption.

The peanut is a soil builder and renovator. If included in the crop rotation and properly handled, peanuts are not exhaustive of soil fertility.

While the average yield of peanuts is only about 34 bushels an acre, with proper methods a yield of 60 bushels of peas and 1 to 1½ tons of forage may reasonably be expected. There are authentic records of yields of 160 bushels of Spanish peas, together with 2 tons of forage, per acre.

The peanut vines, after the removal of all the first-class peas, have a feeding value practically equal to the cost of the field culture of the crop. An acre of first-class peanuts, calculating the yield at a ton of vines, worth from $8 to $10, and 60 bushels of peas, worth $40 to $60, will give an income of $48 to $70. The cost of growing an acre of peanuts is variously estimated at $12 to $25, including seed and fertilizers. These figures show a net return of $36 to $45, which is above the average for the crop as now grown in the United States, but decidedly lower than may be expected under favorable conditions and proper cultural methods.

[A list showing the titles of all Farmers' Bulletins available for distribution will be sent free upon application to a Member of Congress or to the Secretary of Agriculture.]

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Issued March 25, 1911.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 432.

HOW A CITY FAMILY MANAGED A FARM.

BY

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Bureau of Plant Industry.*

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., January 3, 1911.

Sir: I have the honor to submit herewith a paper entitled "How a City Family Managed a Farm," which has been prepared by Mr. J. H. Arnold, Scientific Assistant in the Office of Farm Management of this Bureau.

This paper deals with the experiences of some city-bred people who have made a decided success in farming, though lacking in knowledge of this pursuit when farming was begun.

I recommend the publication of this manuscript as a Farmers' Bulletin.

Respectfully,

Wm. A. Taylor,
Acting Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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HOW A CITY FAMILY MANAGED A FARM.

INTRODUCTION.

This bulletin is a record of the experience of a city family that moved onto a farm in 1892. The father had been a lawyer by profession, the manager for a well-established business firm in one of the principal cities of the Middle West, and was earning a salary of $3,000 a year. At 60 years of age, having been in business about twenty-five years, he was compelled on account of ill health to abandon his profession and business. There were 10 children in the family, ranging from 2 to 21 years of age, of whom 7 were boys.

Under these conditions, with available capital amounting to about $10,000, which had been partly saved in business and partly received by inheritance, the family decided to buy a farm and attempt to solve the problem confronting them, namely, "to make a living, educate the children, and make a pleasant home." This paper will tell how they satisfactorily solved the problem, and while this is not a story of typical farm life, it shows what courage, energy, business ability, and moderate capital may accomplish on a farm. The fact that this farmer has been successful without previous experience or special training, following systematically the ordinary cropping system and methods of tillage, with the exercise of good judgment, shows that the chances for success in farming are as good as in most business enterprises.

An attempt will be made to present such facts about this farm as will enable the reader to comprehend under what conditions and by what means the results were accomplished; hence, a description of the farm and the methods of operating it will be given in some detail. It is not intended to indicate in this description ideal methods of farming. As a model of farm management from the standpoint of maintaining soil fertility and thus obtaining large crop yields this bulletin will have no special interest. The methods of keeping accounts suggested in the tables have been the instruments through which this farmer has kept track of his business, but they are not given as model forms. The description given is rather for the purpose of enabling the reader to get the point of view and spirit of the family in meeting the problems of life and realizing their ideals on a farm.

It is believed that this farmer has, by his experience, answered the chief objections to farming as an occupation and to a farm as a place for establishing an ideal home. These objections, as usually stated, are that farming is not as remunerative as other occupations for the same ability and effort expended, that the family is deprived of desirable educational and social opportunities, and that the labor is too hard and uninspiring, especially for the women. The record will also show how some important social, economic, and technical farm problems have been worked out; for instance, the farm-labor problem, the household problem, the training of children in responsibility in management, and the doing of farm work in a way to meet the requirements of a normal social life and of cultivated intellectual tastes. It is also believed that a narrative of American farm life, such as this, will demonstrate not only the possibilities but the desirability and dignity of farming as an occupation.

While the owner of the farm wishes to avoid publicity, he is willing that the results of his experience be made known in order that other city men may feel safe in attempting to support and educate their families in this manner.

A diary and a financial record were kept on this farm for a period of seventeen years. The facts here given are based upon these records.

DESCRIPTION OF THE FARM.

When the family began country life in 1892 the farm consisted of 300 acres[a] in a much run-down condition. It was an old farm, having been located and surveyed about the middle of the eighteenth century. The old house, which had been built about 100 years ago, was still substantial. In a remodeled form it is now the kitchen of a modern house. Much of the land had been allowed to grow up in bushes and young trees. The barns and fences were out of repair, so that the place as a whole presented a dilapidated appearance. The farm had been rented out and had produced a gross income of about $700 a year.

The location is in the beautiful and fertile region known as the Shenandoah Valley, the middle section of the great Appalachian Valley which extends from the northeast corner of Pennsylvania to central Alabama. It is about 100 miles from a seaboard city and is accessible to railways leading to New York and to the large cities of the Ohio and Mississippi valleys. In this section there are now good turnpike roads. One of these passes the farm and leads to a shipping point 3 miles distant and to the county town of 3,500 inhabitants, 3½ miles distant.

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[a] About 80 acres were added to the farm a few years later, making the entire farm consist at present of 380 acres.

The soil here is residual, formed from a limestone of the Cambro-Silurian age, having a rich brown color and, according to the classification adopted by the Bureau of Soils of the Department of Agriculture, is a clay loam of the Hagerstown series.

CAPITAL AND OTHER RESOURCES.

The inventory taken January 1, 1892 (see Table I), showed that the land with improvements was valued at $55 an acre, the whole farm and equipment being worth $19,707. The debt on the farm, $8,459, and money borrowed for fertilizer, $220, made the total liabilities $8,679, which, deducted from the above assets, left a balance of $11,028, which constituted the "present worth" of farm and equipment at that date.

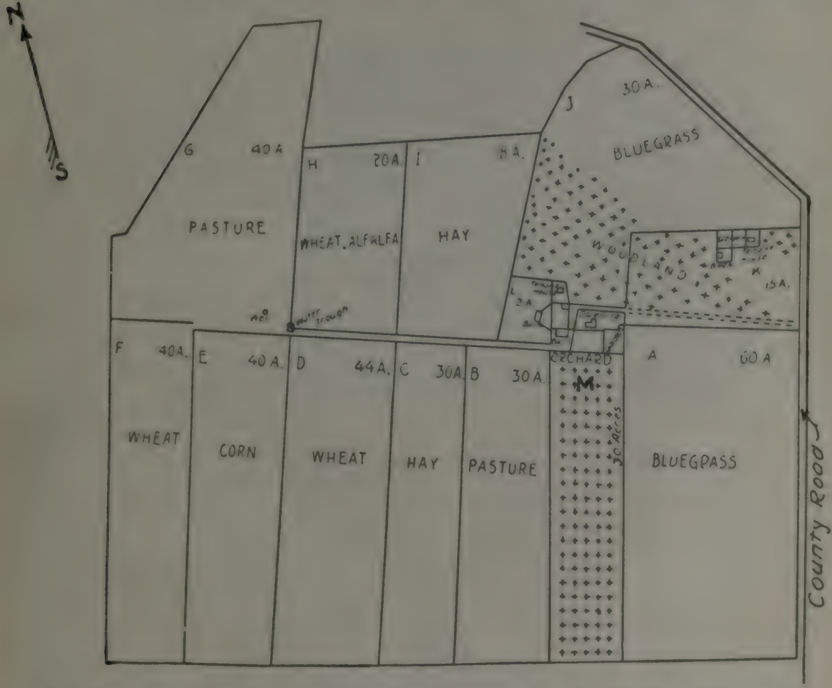

FIG. 1.—Plan of the farm, showing the arrangement of the fields, buildings, etc.

ARRANGEMENT OF THE FIELDS.

The general management of the farm seems to have been well thought out from the first. The farm was laid out originally about as it appears at present, and with slight changes to fit conditions the cropping system was the same as now. The plan of the farm (fig. 1) shows the convenient arrangement of the fields.

Special attention was given to laying out the farm. All the fields except F may be reached within 650 yards of the barnyard. Field F is within half a mile. The fields are as long as can be arranged in accordance with the general farm plan. This is regarded as an important feature in the arrangement, since the time saved during the year in turning corners when plowing and in doing other farm operations is considerable. The gate to each field is placed at the corner nearest the barn, and workmen are required to leave implements at the gate when coming in from the fields. The lane leading to the fields is 30 feet wide; except for the wagon track it is grown up in bluegrass, so there is practically no waste on its account. A well, 80 feet deep, located in field G, supplies water by windmill to a cement trough, which is so placed that it furnishes water in two fields and may be reached easily through the lane from other fields.

CROPPING SYSTEM.

The general crop history of each field may be worked out from the following system of rotation: Corn, wheat, wheat, grass for hay, pasture, corn. Usually two wheat crops follow in succession, and now and then if the stand of grass is not good it is plowed up, put into corn, and reseeded the next year to wheat. On the plat (fig. 1) are shown the crops raised on each field in 1908–9, the plan for the rotation of fields during 1910 being tentatively as follows: B, pasture; C, corn; D, hay; E, wheat; F, wheat; G, pasture; H, wheat; and I, pasture. This will give the following acreage of crops: Wheat, 95 acres; corn, 40 acres; hay, 49 acres, including alfalfa; pasture, 78 acres, besides the permanent pasture.

There are thus 262 acres which have been farmed in the five or six year rotation for nearly seventeen years. During this time the division of crops, which have been run in rotation, has been on the average as follows: Corn, 47 acres; wheat, 80 acres; and hay and pasture, about 135 acres. It is to be added, however, that field M, which is now in orchard, was put in some field crop up to the time the trees were six or seven years old. The bearing orchard, 15 acres, is now 14 years old, and the remainder, 15 acres, is in 1 and 2 year old trees. The young orchard is in corn, making the total acreage of corn 55 acres.

On field H, 5 acres of alfalfa were sown in the fall of 1908. The alfalfa was not able to crowd out weeds, especially the sorrel, which for a time threatened to take the crop. During the spring and summer of 1909 the field was disked twice and harrowed two or three times with a spring-tooth harrow, and in September a heavy coating of lime was applied as a top dressing. On September 23, 1909, the alfalfa was vigorous and the indications were that it would continue to thrive.

WATER SUPPLY AND SEWERAGE.

The barn lots, dwelling, and permanent pasture fields are supplied from a well near the premises. By means of a steam engine the water is lifted into a tank and distributed through pipes where needed. The dwelling is equipped with modern conveniences, such as bathroom, water-closet, lavatories, and hot water. The sewage is distributed through tiles in the orchard. The entire system was planned by the owner and the work was done by labor on the farm.

BUILDINGS.

The buildings have been constructed from the point of view of economy in expense and convenience in use. There are good, substantial horse and cow barns. Their location has been planned in accordance with principles of economy in getting to the fields on the farm. The cow barn and lots are so placed that all the fields may be reached directly. Stock can not interfere with other buildings and premises. Horses may be taken to the fields by opening one gate. The wagon shed (fig. 2) is so constructed that the teams are simply driven through the shed and the wagons left standing in their proper places. No labor and time are consumed in pulling or pushing the wagons into place.

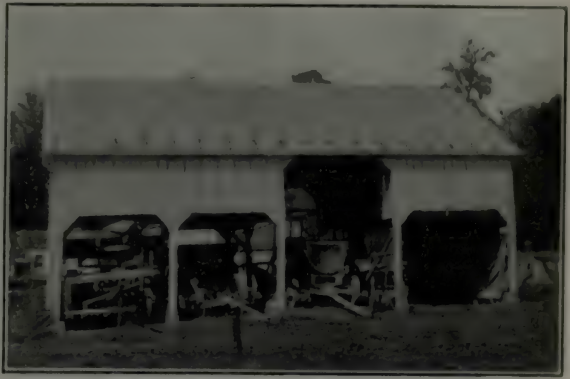

FIG. 2.—A convenient wagon shed, economizing time and labor.

LABOR.

THE SYSTEM OF EMPLOYMENT.

The farm laborers, who are hired by the year, have families, and live in houses built especially for their use. One of these houses is shown in figure 3. Reference to the farm plan will show their location. One acre of ground goes with each of the houses for a family garden. Barn room and the necessary outbuildings for stock belonging to the laborers are also furnished.

The plan of housing laborers in separate quarters is followed, first, to secure privacy and freedom in the home and to relieve the household from extra labor. Second, experience shows that it is possible to secure better service by having men with families. This plan has been followed with but few exceptions from the first and has been quite satisfactory to the family and to the men. As a rule these men have been recruited from factories, railroads, and mines. They are secured by offering inducements not usually given on farms. Ten hours of labor, for instance, is all that is required, and usually a part holiday on Saturday. Sometimes a whole day is given as time off to work their gardens, etc. Any special service or extra good work is rewarded in some way.

The standard money wages paid is $200 a year. In addition a dwelling, 1 acre of garden, one cow and pasture, and firewood are furnished. Remuneration beyond this is dependent upon the quality of service. If satisfactory service has been given during the first year $25 extra is paid in cash and 5 barrels of corn to fatten hogs. After two years of satisfactory service $50 in cash and 10 barrels of corn are given at the end of each year. If wheat is put in satisfactorily and the crop is good, 30 bushels of wheat in the mill is added to the income of the laborer's family. The laborer may keep as many fowls as he chooses, inclosed. He has the same area of garden as his employer's family and may sell as much as he likes from it.

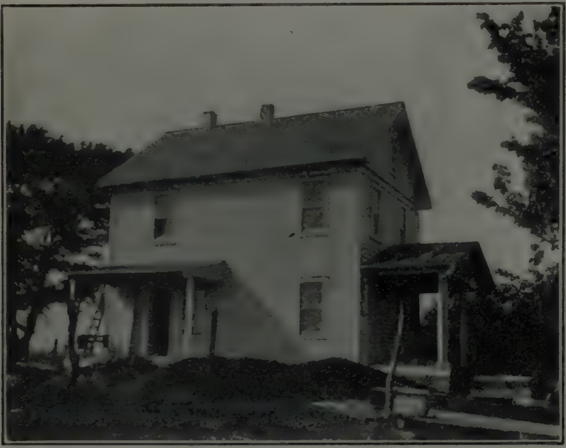

FIG. 3.—A laborer's house, planned by the owner and built to a great extent by farm labor during the winter of 1909–10.

This plan has enabled the majority of the laborers who have lived on this farm to accumulate a sufficient amount of capital to take up farming for themselves. Some have become owners of farms. The employer takes pains to teach his men good farming methods.

At least one of the laborers is expected to have sufficient mechanical ability to do all needed repairing and to help with the construction of buildings on the farm. For this purpose there is a well-equipped blacksmith and carpenter shop. This provides work on rainy days and in the winter.

RELATION BETWEEN OWNER AND LABORER.

The proprietor takes a personal interest in the welfare of the laborer and his family. He holds that good work can not be secured unless the laborer is contented and gives his services cheerfully. Mutual good will develops when the employer is careful in the selection of his men and permits them to share in the general success of the farm. In 1909 the best laborer on the farm, the man longest in service, concluded to begin farming for himself. The employer bought 20 acres of land for him, which will be paid for in small sums, as he can afford to make payments.

ECONOMICAL USE OF LABOR.

The economical use of labor is one of the most serious problems in farming. This farmer has plans drawn for the remodeling of buildings, the changing of fences, and the erection of new buildings. "I make these plans as they come into my mind," he says, "and when labor can not be profitably used in the fields it is employed in carrying out these plans. As a rule, I plan ahead for my farm work and find that it pays, since we lose no time and labor can always be profitably employed."

During the winter of 1909–10 a new tenant house was planned by the owner and largely constructed by the regular farm labor, with such other help as could be obtained in the community. The large barn on the farm was built entirely by the men and boys of the family and two laborers.

FAMILY DISCIPLINE AND OCCUPATION.

The occupations and labor of the family are not arranged from the standpoint of economic results, but in accordance with the principle stated in the introduction—that of properly training the children and making the home pleasant.

In the home the children, from the time they were old enough to perform any service, have been required "to do something for the profit or welfare of the family before having any breakfast." The work done by the family in the house was systematized in such a way that each member when old enough assumed responsibility for some of the work. This system of training is adapted to the requirements of farm life. There have been developed on the farm industries such as dairying, poultry keeping, gardening, orcharding, and general farming. At the present time one son makes the apple orchard his specialty. A daughter is responsible for the poultry and another for the marketing of produce and the bookkeeping. The mother does the cooking and superintends the dairy. The father superintends the whole farm, sees that crops are properly put in and cultivated, and that the stock is well cared for. He is in touch with every operation on the farm and inspects all the work that is done.

Special attention is given to the care of work horses. Every evening the shoulders of work horses are bathed with cold water. At noon in summer the laborers are given an extra half hour to unharness and reharness the horses. As a result of this special care, sore shoulders on horses are seldom known on this farm.

THE HOUSEWORK PROBLEM.

No regular house servants are kept in the home. The work of housekeeping is done by the mother and two daughters. The laundry work is done outside. All heavy work, and such labor as caring for the garden, etc., is done by the men. The cooking arrangements are planned to economize labor and make it as easy as possible. A hot-water tank is connected with the plumbing system, so that plenty of hot and cold water can be had at any time. This arrangement, combined with a large sink from which waste is carried to the sewer, eliminates most of the conditions which tend to make housework drudgery. Utensils are kept in their proper places, so that they can be reached with the fewest possible steps.

THE FARM GARDEN.

The garden, consisting of about 1 acre of land, is an important feature in the management of this farm. The crops shown on the diagram (fig. 4) are those planted in 1909. Besides the vegetables and small fruits for family use, the garden brings an income of about $200 a year, the products being exchanged for groceries. This pays the expenses of the table. The principal money crops from the garden are kale, spinach, winter onions (sold in early spring), tomatoes, and cantaloupes. Kale and spinach are not common crops in this section and a ready market has always been found for them. Others, however, are beginning to raise kale on their own account, so that more spinach is now being raised on this farm. Prices have ranged from 40 to 60 cents a bushel for kale and 60 to 80 cents a bushel for spinach. From 250 to 300 bushels an acre is considered a good crop. Besides being raised for the market, kale is used as a general winter cover crop in the garden. On September 23, when the writer last visited the farm, kale was coming up in all places not in regular garden crops. It is found that kale plowed under in the spring puts the ground in fine condition for cantaloupes.

A specialty has been made of raising late tomatoes to be put on the market when this fruit is scarce. Tomatoes are sold from this garden about the last of October and in November. Most of the products are sold by telephone to the merchants in the town and villages in the county.

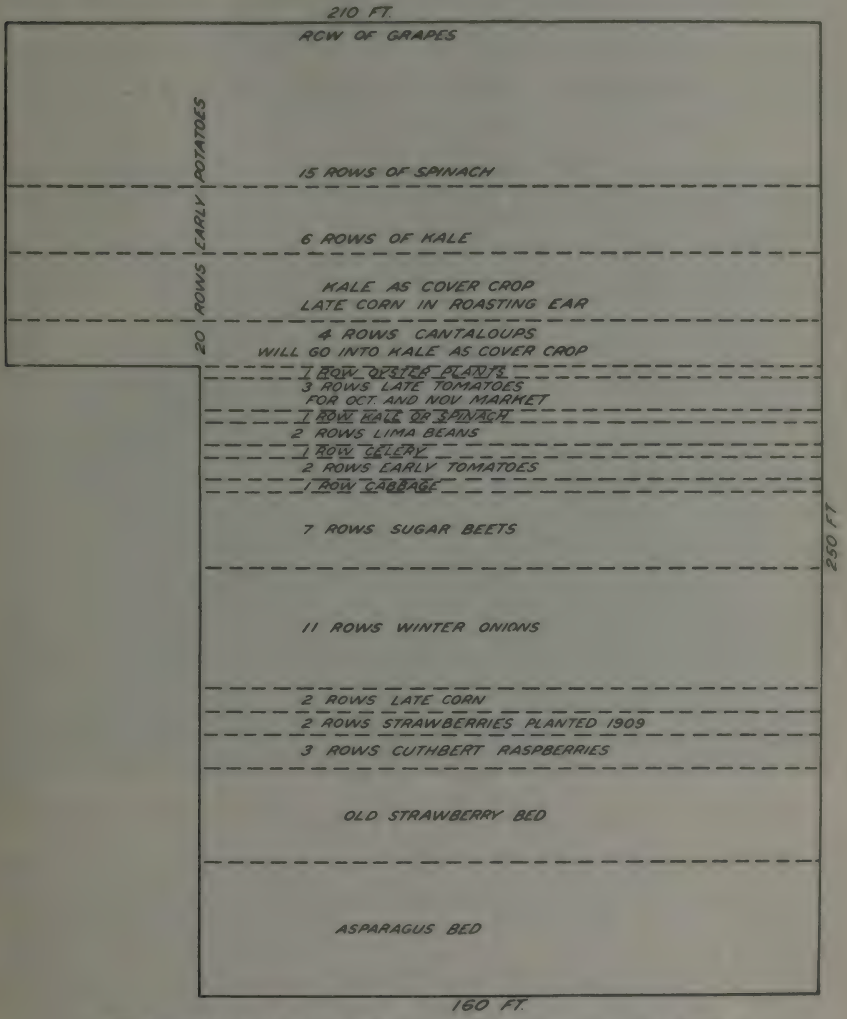

FIG. 4.—Plat of the farm garden, showing the crops grown in 1909.

A row of grapes occupies the space along the fence at one end of the garden. There are also four short rows outside, not marked on the diagram. The vines are trimmed in winter, but receive no other special care. When the fruit is formed in early spring the bunches are bagged with 2-pound grocery bags, tied securely with a string about the base of the stem. It is stated that these bagged bunches will stay well preserved on the vines until frozen off. The bunches still hanging on the vines unbagged were badly diseased and rotted on September 23.

THE ORCHARD.

Field M (see fig. 1) is now planted in orchard, 15 acres of which is in the bearing stage. With the exception of a few old trees near the house this orchard is 12 to 14 years old. The trees were planted in the ordinary manner about 30 feet apart, cultivated in crops for six to ten years, then seeded to grass and clover. At two different times a bushel of wood ashes was put around each tree. This year manure was hauled between the rows and spread about 10 feet from the trees. Since it has been in grass the orchard has been pastured by sheep and hogs. The branches are thinned out in the dormant season, being trimmed mostly at the top. The trees are sprayed four times a year, twice for the San Jose scale and twice for the codling moth. There is a space of about half an acre with no trees. The orchard had become infested with the San Jose scale and the infested trees were cut out before the proprietor learned how to deal with this pest.

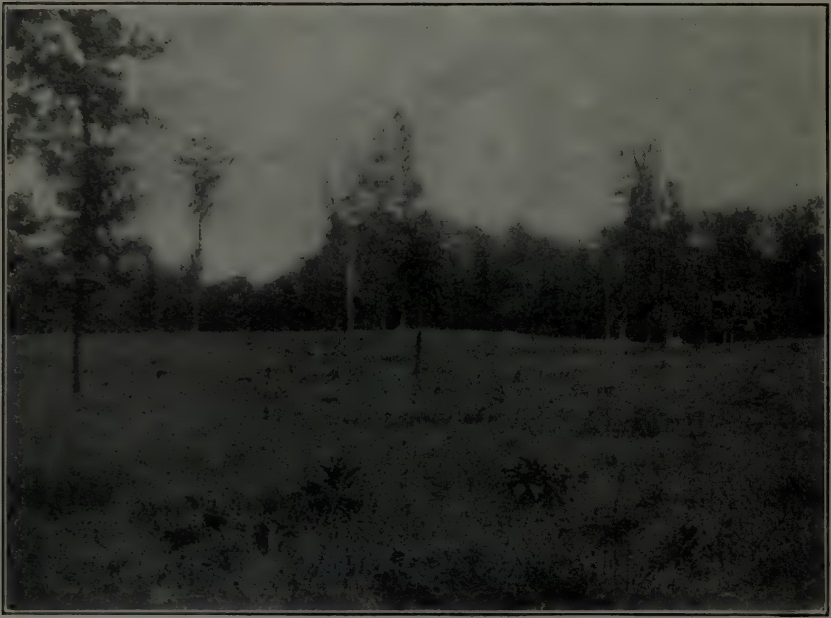

FIG. 5.—A section of the woodland and bluegrass pasture on the farm, showing where the trees have been cut off to get a growth of bluegrass.

Reference to the table of receipts and expenditures will show that this orchard has been bringing in a substantial income for three years. Last year 800 barrels of apples were marketed at $2.10 a barrel. The varieties grown for market are the Ben Davis and York Imperial. It is planned to increase the size of the orchard until it reaches about 100 acres.

WOODLAND AND PERMANENT PASTURE.

About 30 acres of the farm in one tract is in forest, containing many large and valuable oak, hickory, elm, and walnut trees. The field marked "K," in which are many of these trees, is known as "The Refuge." Squirrels play without fear in this field. Where the trees have been thinned out in the woodland, bluegrass has come up luxuriantly (fig. 5), so that the greater part of fields A, J, and K furnish fine pasture in the early spring.

STOCK.

In the inventory of January 1, 1905, 182 head of live stock were recorded, and on January 1, 1909, there were 200. Averaged for the past five years the proportion of different kinds of live stock is about as follows: Horses, 10; cows and stock cattle, 40; young cattle, 10; hogs, 35; and sheep, about 100. On the average about 160 acres remain in pasture. To show that this farm has about the right area in pasture, the following estimate of pasture area for each class of stock is given:

40 cows and stock cattle	80 acres.[a]
10 young cattle	15 acres.
35 hogs	10 acres.
100 sheep	40 acres.
10 horses and colts	15 acres.
	160 acres.

The dairy department of the farm maintains on the average 8 to 10 cows. Butter is made and sold in the local markets. It is found to be more profitable to buy young steers and keep them a year than to buy and feed the same year.

Sheep have always been kept on the farm and the profit in them is very satisfactory.

Ten horses and 2 or 3 colts are kept on the place. Seven horses are used for farm work and 3 for driving.

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[a] These figures should be studied in connection with the statistics presented in "Cropping Systems for Stock Farms," by W. J. Spillman, Yearbook of Department of Agriculture for 1907.

TILLAGE.

Three-horse plows are run from 9 to 10 inches deep for both corn and wheat. No guessing is allowed on this point, since the furrows are measured frequently to see that the required depth is maintained.

The ground for wheat is prepared in the following manner: As soon after harvest as possible the stubble ground is plowed. It is harrowed, then rolled and harrowed again, the second time with a spike-tooth harrow. A spring-tooth harrow precedes the drill. The wheat is sowed about September 25. Wheat to follow corn is put in as soon as possible after the corn is cut, the land being prepared by running a disk harrow over the field and then a spring-tooth harrow. Sometimes the spring-tooth harrow alone is deemed sufficient. The land is then drilled the same as the plowed ground.

Corn is planted on land which has been in pasture. Before plowing the ground is covered with stable manure. After plowing it is pulverized with a disk harrow and cross-harrowed before the planter. It is harrowed once after planting and then cultivated with two-horse cultivators, the last time or two very shallow.

FERTILIZERS.

The manure spreader is regarded as one of the most important implements on the farm. By means of it, it has been possible during the past few years to cover about 75 acres of the farm each year with stable manure.

It is a common practice in this section to use commercial fertilizers when sowing wheat and grass. The fertilizer is mixed on the farm. It consists of a mixture of one half of ground raw bone, containing 22 per cent of phosphoric acid and 2½ per cent of nitrogen, and one half of South Carolina ground rock, containing 16 per cent of phosphoric acid. It has not been the practice on the farm to plow under green crops, although the benefit of such practice is recognized. A straw mulch has been put on part of a field at different times and plowed under. The results have been good. One year the plowing under of straw alongside of land well manured gave about the same results as manured land. In the year 1909 on field D, a part of the wheat stubble was mowed soon after harvest to serve as a mulch. On the ground that was mowed the clover was taller and more vigorous on September 2. The difference was to be seen also on September 23. The year 1909 being very dry, this covering no doubt prevented the evaporation of moisture and thus aided the clover in making a better growth.

FINANCIAL RECORD OF THE FARM.

INVENTORIES.

A simple but quite complete record of results on this farm has been kept from the time the farm was purchased until the present time. This is in the form of a diary and a bookkeeping record. On January 1 of each year an inventory was made. Tables I, II, and III show inventories for the years 1892, 1905, and 1909, which give a good idea of the development of the farm and particularly of the increase in its value. Under the heading "Plant" are given the real estate and the live stock and machinery which are used in operating the farm. Under the heading "Materials and supplies" are given feed and salable grain and animal products; also live stock which may be sold or used to replace older stock for breeding and dairy purposes.

In 1892 the value of the plant was $18,167; in 1905 it was $32,365; in 1909 it amounted to $41,972. It will be seen that the value of the plant has more than doubled during the seventeen-year period. The net income has more than doubled also, so that the increased valuation of the real estate could properly be based on the income.

TABLE I.—*Inventory of the farm, January 1, 1892.*

Item.	Value.	Total.
ASSETS.[a]		
Plant:		
Land, including improvements, etc., 300 acres, at $55 an acre		$16,500
House furniture, etc		1,000
Live stock—		
2 horses, at $100	$200	
8 cows and heifers, at $25	200	
8 hogs, at $4	32	
		432
Machinery and tools—		
Farm wagon	50	
Buggy	50	
Harness, etc	30	
Drill and plows	85	
Harrow	18	
Forks	2	
		235
Materials and supplies:		
Feed and salable products on hand—		
Hay for stock, 30 tons, at $5	150	
Grain for stock, 70 barrels corn, at $2	140	
		290
Live stock—		
2 colts, at $60	120	
27 head stock cattle, at $30	810	
		930
Growing wheat, 80 acres		320
		19,707
LIABILITIES.		
Debt on 300-acre farm	8,459	
Debt for fertilizer and drill	220	
		8,679
Present worth of farm and equipment		11,028

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[a] The classification of items in these inventories was made by the writer and is intended to show approximately the amount of capital invested in land and equipment and the value of farm products on hand. The part of material and supplies needed for the plant equipment is necessarily indefinite. It is therefore regarded as more desirable to include the value of such items under "Materials and supplies."

TABLE II.—*Inventory of the farm, January 1, 1905.*

Item.	Value.	Total.
ASSETS.		
Plant:		
Land, including buildings, etc., 380 acres at $75 an acre		$28,500
House furniture, etc		1,500
Live stock—		
7 horses	$550	
7 cows	280	
1 bull	60	
4 brood sows	40	
87 sheep	435	
		1,365
Machinery and tools—		
Farm machinery and implements	400	
Hand tools	100	
Carriages and wagons	400	
Harness	100	
		1,000
Materials and supplies:		
Feed and salable products on hand—		
30 tons of hay	240	
250 barrels of corn	562	
Bacon, flour, and potatoes	150	
Fodder and straw	100	
Oats and flaxseed meal	60	
		1,112
Live stock—		
4 heifers	100	
7 yearlings	140	
3 calves	30	
37 head feeding cattle	1,245	
23 shoats	75	
2 colts	100	
		1,690
Growing wheat, 92 acres		555
		35,722
LIABILITIES.		
Due on farm		8,500
Present worth of farm and equipment		27,222

TABLE III.—*Inventory of the farm, January 1, 1909.*

Item.	Value.	Total.
ASSETS.		
Plant:		
Land, including buildings, etc., 380 acres, at $95 an acre		$36,100
House furniture, etc		1,500
Live stock—		
6 work horses, 3 driving horses	$1,350	
17 cows, at $50	850	
1 bull	50	
3 brood sows	60	
1 boar	12	
100 sheep	700	
		3,022
Machinery and tools—		
Farm machinery and implements	600	
Hand tools	150	
Wagon and carriages	400	
Harness	200	
		1,350
Materials and supplies:		
Feed and salable products on hand—		
100 barrels of corn	300	
70 tons of hay	560	
Bacon, flour, and foodstuffs on hand	150	
Oats	20	
Fodder and straw	100	
		1,130
Live stock—		
2 colts	120	
18 fat cattle	1,260	
15 heifers and calves	375	
34 hogs	170	
		1,925
Growing wheat, 98 acres		585
Total resources		45,612
LIABILITIES.		
Due on farm		6,503
Present worth of farm and equipment		39,109

RECEIPTS AND EXPENDITURES.

The items in Table IV are taken from the books kept on the farm. This record includes five years—from 1904 to 1909. Some of the items in this table are estimates: for instance, grain and hay fed to stock. The amount of such materials produced on the farm is known quite accurately, however. The amount sold plus the amount on hand subtracted from the amount produced gives the amount of such products fed. The records are, of course, far from complete, yet the net income is shown with a fair degree of accuracy.

TABLE IV.—*Receipts and expenditures on the farm, 1904 to 1909, inclusive.*

Item.	1904.	1905.	1906.	1907.	1908.	1909.
RECEIPTS.						
Cattle, including fat cattle sold	$1,381.87	$2,684.39	$200.00	$500.00	$1,937.00	$700.00
Sheep, lambs, and wool	400.00	400.00	500.00	550.00	550.00	750.00
Wheat	1.480.30	1,230.00	751.00	1,557.00	1,157.00	1,682.00
Corn	765.00	969.50	600.00	1,000.00	750.00	900.00
Oats	112.00				60.00	75.00
Hay	490.00		700.00	800.00	900.00	960.00
Pork products	72.00					
Live hogs	50.00	135.00	300.00	200.00	475.00	750.00
Poultry, dairy, and garden products	350.00	375.00	400.00	400.00	600.00	600.00
Wood	180.00					
Apples		500.00		1,427.00	512.00	1,680.00
Total receipts	5,281.17	6,293.89	3,451.00	6,434.00	6,941.00	8.097.00
EXPENDITURES.						
Labor [a]	500.00	400.00	450.00	500.00	700.00	700.00
Taxes	170.00	150.00	138.00	145.00	140.00	168.00
Farm supplies	250.00	300.00	300.00	300.00	200.00	400.00
Interest on debt	360.00	360.00	360.00	344.00	260.00	240.00
Fertilizer	150.00	135.00	116.50	147.86	185.39	185.39
Seed	211.00	212.00	150.00	150.00	197.50	188.00
Grain and hay for stock (produced on farm and fed)	500.00	550.00	400.00	600.00	750.00	600.00
Cattle bought for feeding	650.00	1,763.00			781.24	
Hogs for feeding		36.00				
Extra labor picking apples, etc				300.00		418.00
Total expenditure	2,791.00	3,906.00	1,914.50	2,486.86	3,214.13	2,899.39
Net income [b]	2,490.17	2,387.89	1,536.50	3,947.14	3,726.87	5,197.61

[a] The labor of the family is not counted as an item of expense.

[b] Net income, as understood on this farm, includes interest on investment, profits, and reward for the labor of the family.

The accompanying diagram (fig. 6) shows the net income during the period from 1892 to 1909. It also shows the gross value of wheat and corn produced during these years. The low income in the year 1906 is largely accounted for by the severe illness of the father during this year. The advance in the income the next year, 1907, was due to more than average yields of all kinds of crops, but there began to come in a new crop—apples—the gross sales of which amounted in 1907 to $1.427. This crop is now the most profitable on the farm. During the year 1909 the sales of apples amounted to $1,680.

CORN AND WHEAT.

Tables V and VI relate to corn and wheat production. The average yield of wheat during these years was 18 bushels an acre; that of corn nearly 40 bushels (eight barrels) an acre. These were fair yields, somewhat above the average for this region. The average cost per acre of raising wheat, as given in this table, is $6 an acre. In this estimate the rent of land and the cost of superintendence are not included. It is believed that these figures fairly represent the cost of raising wheat in this region.

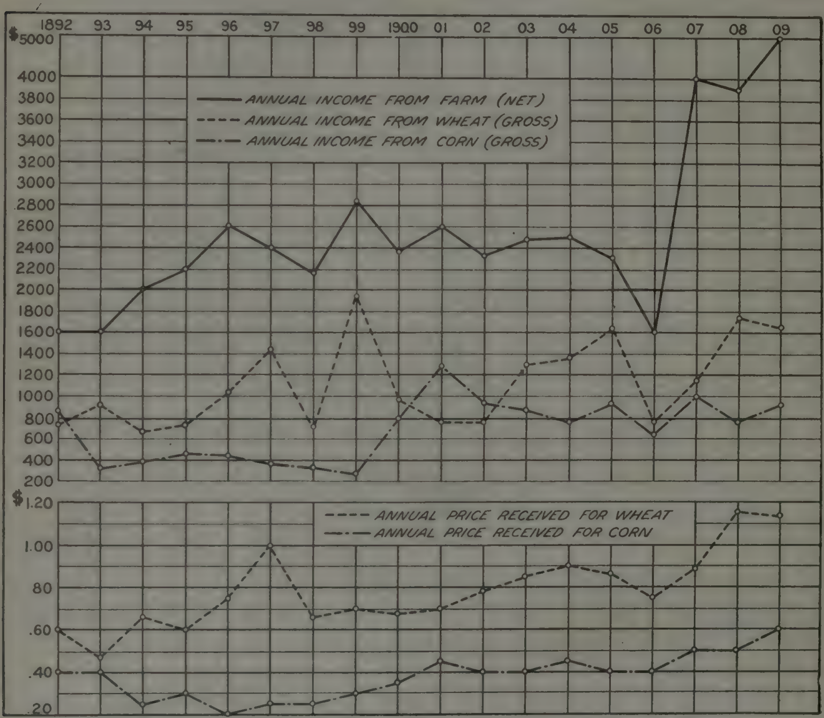

FIG. 6.—Diagram showing the annual net income from the farm and the annual gross income from wheat and corn.

The tables show no record of the cost of raising corn. The owner estimates, however, that it costs more to raise corn than wheat.

Hay on this farm is handled by modern machinery. It has produced on the average about 1¼ tons per acre.

TABLE V.—*Yield and cost of wheat crop, 1892 to 1908, inclusive.*

Year.	Area.	Yield per acre.	Cost of fertilizer per acre.	Total cost per acre.[a]	Total cost per bushel.	Selling price per bushel.	Profit per acre.
	Acres.	*Bushels.*					
1892	63	21	$2.70	$7.56	$0.36	$0.60	$5.04
1893	73	26¾	2.12	5.78	.22	.47	6.64
1894	55	19	1.20	4.69	.24	.66	7.85
1895	68	18	.90	4.65	.25	.60	6.15
1896	55	25	1.12	4.30	.17	.75	14.10
1897	64	22	1.35	5.95	.27	1.00	16.05
1898	70½	15	1.64	6.32	.42	.66	3.58
1899	112	23½	1.41	6.41	.27	.70	9.92
1900	82	17	1.25	6.04	.35	.68	5.52
1901	90	12½	1.70	6.71	.53	.70	2.03
1902	100	10	1.17	6.30	.63	.78	1.50
1903	106	15	.98	4.80	.32	.85	7.95
1904	91	17	1.17	6.84	.40	.80	6.76
1905	87½	20	1.55	6.86	.34	.86	10.34
1906	77½	13	2.38	7.40	.57	.74	2.21
1907	78	16	1.35	6.92	.43	.89	7.32
1908	95	16	2.00	5.47	.34	1.15	12.93

[a] The cost of labor, seed, and fertilizer is included in the estimated cost for each year, the labor being estimated on the basis of what it would cost to hire the work done at the market price.

TABLE VI.—*Yield of corn and price per barrel of crop, 1892 to 1908, inclusive.*

Year.	Area.	Total yield.	Yield per acre.[a]	Price per barrel.
	Acres.	*Barrels.*	*Barrels.*	
1892	44	440	10.0	$2.00
1893	55	169	3.1	2.00
1894	45	291	6.5	1.25
1895	50	293	5.9	1.50
1896	55	445	8.1	1.00
1897	40	306	7.6	1.25
1898	40	251	6.3	1.25
1899	30	187	6.2	1.50
1900	60	438	7.3	1.75
1901	55	545	9.9	2.25
1902	58	488	8.4	2.00
1903	60	450	7.5	2.00
1904	38	340	9.0	2.25
1905	42	491	11.7	2.00
1906	40	320	8.0	2.00
1907	44	397	9.0	2.50
1908	44	300	6.8	2.50

WHAT THE FARM HAS BEEN MADE TO ACCOMPLISH FOR THE FAMILY.

An attempt has been made thus far in the record given to set forth the actual operations of the farm. They are not set forth as models. On the whole, however, they represent good farm practice.

To just what degree this family has been successful depends upon the point of view taken. The financial record might seem to some disappointing, considering the amount invested and the number of people taking part in the labor producing these results. In terms of dollars and cents it might not be considered a paying business. On the other hand, if we consider the results produced through the use made of the net income, the farm tells a different and a more satisfactory story. As was stated in the introduction, the intention in going on the farm was not primarily to increase the income, nor were money profits more than a secondary consideration. In the first place, the father was ill and was told by his physician that he could not live another year in the city if he continued his business. Some of the children were very young, while others were ready to enter the university. In order to measure success from the standpoint of the father and the mother we must know about the family and what it has accomplished and is doing.

The boys have graduated from a State university and the girls have been educated by private tutors and in girls' schools. At the present time two sons are lawyers, one a minister, one a professor, one a civil engineer, and one a farmer. The education of the children has cost the farm about $10,000. During the time the children were being educated there was no income except from the farm. At the present time these sons and daughters are profitably employed in honorable and useful occupations. While but three remain on the farm, one son and two daughters, all are following their present callings with the end in view of buying farms on which to make their homes.

Each year all members of the family, including grandchildren, spend their vacations on the farm. This is usually in harvest and haying time, so that no extra labor is hired during these farm operations.

The father declares that he has improved in health every year since coming on the farm. Now 76 years of age, he superintends all farm operations and knows the details of everything that is going on. He still enjoys good health and is fairly strong, being able to walk to every part of the farm. It must be remembered that he came on the farm long after most farmers begin to think of retiring, being then 60 years of age.

The farm work is not regarded as drudgery, and there is an atmosphere of refinement about the home that indicates a wholesome life on the part of the family. Everyone on the farm is occupied with some kind of work, and the farm operations go on in a businesslike manner, but no one is rushed or overworked. The mother is well preserved and vigorous, with no trace of overwork, though she has always been active in the management of the home and farm. She believes that the farm life, on the whole, has been easier for her and more enjoyable than the life in the city. Every member of the family is in love with farm life and expects to live on a farm when conditions permit.

SOCIAL AND AGRICULTURAL PROBLEMS SATISFACTORILY SOLVED.

(1) A professional man, with no previous experience as a farmer, with a large and expensive family, is able to rear and educate his children on the income of a well-located farm of 380 acres of good land with a modernized dwelling upon it (fig. 7). On a salary of $3,000 in the city the same amount of money could not have been expended on their education and a fair standard of living maintained. This fact is indicated in the inventory of 1892, which showed the present worth of the family to be $11,028, about $5,000 of which represented the savings of 22 years, the remainder being inherited. The present worth of the family, as represented by the farm in 1909, is $37,662. About $15,000 of this increase in present worth is due to increase in land values. This leaves nearly $12,000 to represent savings during the period when the children were receiving their education.

FIG. 7.—The family home, built for comfort and economy of labor in household work.

Business training and experience have been important factors in the success achieved. The father, who, at the age of 76, still keeps in touch with all the farming operations, says: "My life as a soldier taught me how to obey and command, how to economize and endure. My life in the city as a lawyer in charge of a title and trust company taught me system and business methods, all of which were valuable to me on the farm."

A fact of special importance in this record is that these results were accomplished by following the established methods of farming. The yields are a little above the average for the community, because of more thorough tillage methods, but no extraordinary yields are recorded. The diary kept by the farmer and the history as written show keenness and foresight in adjusting crop and stock products to market conditions. The management of farm operations, although adjusted to the comfort and tastes of the family, have been conducted strictly on economic principles. From this standpoint a problem of great interest and importance has been worked out on this farm.

(2) The members of the family believe they have had more opportunities in the way of general culture gained by travel, etc., than would have been possible for them in the city. Socially they think there has been no essential loss; in fact, it is quite probable that the farm life has given better opportunities for culture of the most wholesome kind than the city would have afforded.

(3) The labor problem has been satisfactorily solved on this farm. With such wages as the farm could pay, the laborers have been able to accumulate sufficient property in a few years to take up farming for themselves. At the same time the women of the family have been relieved of extra work and responsibility necessarily attending the boarding and lodging of laborers; also the family life has been more homelike. The service secured in this way has been good, and on the whole the relations between employer and employed have been remarkably satisfactory.

(4) It has been found practicable and beneficial to train the children through occupations which require them to assume responsibility. As an inducement to make the chosen line interesting and as an incentive to industry, the profits of the industries on the farm went to the children managing these departments. It is the testimony of all who know the family that the children are all efficient managers.

(5) It has been demonstrated on this farm that an acre of garden, without any particular specialization in crop methods, can be made to pay the expenses of the table for a large family.

(6) The value of agricultural literature to the farmer is clearly demonstrated on this farm. Asked what benefit such literature had been to him, the father replied: "I would have been blind without it." The knowledge of spraying for San Jose scale saved a valuable orchard which is to-day the most profitable part of the farm. Fifteen or twenty well-chosen works on farming, with selected bulletins from State experiment stations and from the United States Department of Agriculture, constitute an important part of the farm library. Several standard agricultural papers are also taken.

A SERIOUS PROBLEM.

Since 1905 there has been a marked increase in the income of this farm, due principally to the apple crop. About the same time a sharp advance took place in the price of field crops and of live stock, and these prices have advanced since. As a result of these conditions the net income for 1909 was $5,197.50, the largest in the history of the farm. That the advance in income is not due, however, to increased productivity of the soil is disclosed by the records of the farm. An examination of Tables V and VI shows that wheat has decreased in yield per acre to a marked extent during the last half of the seventeen years. The average yield of this crop during the first half of this period was 21 bushels, and during the last half 15 bushels per acre. Corn, however, made an average of 35 bushels per acre during the first period of eight years and 43.5 bushels during the last nine years. On the other hand, clover and timothy have about held their own in yield during the entire period, the average being about 1¼ tons per acre. The increase in the yield of corn may be accounted for largely by an important change in the method of tillage. The proprietor of the farm now gives corn shallow cultivation during the last two times, whereas formerly he followed the usual custom of cultivating deep at all times and "hilling up" the corn at the last cultivation. This method of cultivation, together with an increase in the depth of plowing, which is now 9 to 10 inches, has greatly increased the yield of corn. It is to be noted also that a small quantity of lime, 300 to 400 pounds per acre, was put on the land at intervals with beneficial results to clover and thus indirectly to corn.

A statement in a letter lately received from this farmer shows that the soil has been held up to a normal standard of productivity with great difficulty and is in danger of decline. He says: "We are not getting the results for our labor and land that we should. I think we must work out a rotation that will give us larger yields of wheat. This I think can be accomplished by getting rid of the sorrel in our land and growing more clover and other leguminous crops. The wheat crop is the measure of all other values as a rule, and if we can grow more and cheaper wheat it will do more to reduce the cost of living than almost anything else."

This farm has a very good financial record, due to intelligence and the application of business methods in management. But one of the essential factors in the management of a farm is maintaining or strengthening those soil conditions which are favorable to the production of such value-producing crops as it seems desirable to raise.

If such conditions are not maintained certain weed pests, which find the soil favorable, come in and take the place of cultivated crops.

The farmer is often misled by this fact and regards the presence of weeds as the direct agent preventing the vigorous growth of crops, whereas the real cause may be the lack of a proper environment for the crops. For this reason attempts are often made to subdue weeds by cultivation alone, which is only partially successful and adds unnecessary expense.

The fact that sorrel is a persistent and troublesome weed on this farm is evidence that fundamental conditions of soil are defective and that other methods besides cultivation must be planned to subdue it and allow the desirable crops to take its place.

It is suggested, therefore, that a rotation of crops and some system of cultivating the soil be adopted which will build up and maintain the land in a condition which will better enable the cultivated crops to combat the weed enemy in the struggle to possess the soil.

The practice of liming the soil is found to be beneficial in this region, stimulating the growth of clover and thus tending to eliminate the sorrel. On this farm lime could be applied at little expense, since in many places limestone rock crops out at the surface. This rock could be blasted out and either ground or burned to be scattered on the land. This could be done at shorter intervals than formerly or a heavier application made of 1,000 or 2,000 pounds to the acre.

Besides the use of lime and commercial fertilizer the following rotations are suggested, the practice of which would speedily supply humus and nitrogen, materials which are essential in maintaining the soil in a condition favorable to field crops:

Corn plus crimson clover or rye and hairy vetch.
Cowpeas.
Wheat.
Hay (6 pounds of clover seed the following spring).
Pasture.

Crimson clover has not generally proved successful here and should be tested on a small area before sowing a large quantity. Three conditions at least are essential for a satisfactory growth of crimson clover. The soil must be inoculated with the proper bacteria, it must contain a fair amount of humus and nitrogen, and the seed must be sown sufficiently early in order to make a vigorous growth before winter.

Rye and hairy vetch are adapted to more general conditions, may be sown later than crimson clover, and will grow under conditions that will not produce crimson clover. It is essential that the land be artificially inoculated for hairy vetch unless the bacteria are known to be in the soil. The 6 pounds of clover seed to be sown the spring following the hay crop are essential in getting a stand of clover to plow under the next year for corn.

Alfalfa may be grown successfully on clean and fertile land in this region. When these conditions can be met the following rotation is advised:

Corn plus crimson clover or rye and hairy vetch.
Cowpeas.
Wheat.
Alfalfa.
Alfalfa.
Alfalfa.

On land that is fairly rich in nitrogen and humus, if the problem were simply to maintain fertility, a shorter rotation could be adopted by cutting out one year of wheat on this farm, making it a four-year rotation, which would have the effect of growing more legumes. It has been demonstrated that such a rotation as this would gradually increase the nitrogen and humus content of the soil. Minnesota Agricultural Experiment Station Bulletin No. 109 gives the results of experiments carried on in several places through a series of 10 years with a rotation of corn, wheat, hay, and pasture, and it was found that the humus and nitrogen could not only be maintained but increased.

One or the other of the two rotations first suggested will no doubt be adopted on this farm, at least until the land is built up to a normal standard.

FARM IMPLEMENTS AND THEIR COST.

The following is a complete list of the machinery and implements used on the farm described and their cost:

List of farm implements and their cost.

1 seven-foot-cut wheat binder	$135
1 six-foot-cut wheat binder—old—for use in case the other gets out of repair	100
1 five-foot mower	35
1 four-foot mower	30
1 manure spreader	80
1 ten-spout wheat hoe drill	75
1 eight-spout wheat disk drill	60
2 disk harrows (one tongueless)	50
2 spring-tooth harrows	27
2 spike-tooth harrows	24
2 two-horse chilled plows	12
2 three-horse chilled plows	18
2 walking wheeled double cultivators	50
4 double-shovel plows	10
1 double smoothing harrow	12
1 two-row disk corn planter	40
1 single-row corn planter	12

1 iron roller	$12
1 plank drag	2
1 hay loader	60
1 side-delivery horserake	40
2 single-horse cultivators	14
2 four-horse wagons	120
1 two-horse wagon	50
2 road beds for wagons	40
2 hayracks	20
1 steel spring-tooth hayrake (10 feet)	20
1 spring-tooth weeder	9
	1,157

FARMERS' BULLETINS.

Bulletins in this list will be sent free, so long as the supply lasts, to any resident of the United States, on application to his **Senator, Representative, or Delegate in Congress,** or to the Secretary of Agriculture, Washington, D. C. *Because of the limited supply, applicants are urged to select only a few numbers, choosing those which are of special interest to them.* Residents of foreign countries should apply to the Superintendent of Documents, Government Printing Office, Washington, D. C., who has these bulletins for sale. Price 5 cents each to Canada, Cuba, and Mexico; 6 cents to other foreign countries. The bulletins entitled "Experiment Station Work" give briefly the results of experiments performed by the State experiment stations.

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Issued April 14, 1911.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 433.

CABBAGE.

BY

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Horticulturist, Bureau of Plant Industry.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., January 6, 1911.

Sir: I have the honor to transmit herewith a paper entitled "Cabbage," prepared by Prof. L. C. Corbett, Horticulturist of this Bureau, and recommend that it be published as a Farmers' Bulletin.

Respectfully,

Wm. A. Taylor,
Acting Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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CABBAGE.

INTRODUCTION.

Cabbage is one of the most universally cultivated of our garden plants. Although it is one of the coarser vegetables it finds a place in the home garden as well as in the market garden and truck farm. In some sections of the United States cabbage is extensively grown as a farm crop.

According to the last census New York State grew more than 25,000 acres of cabbage; Pennsylvania, nearly 11,000; while Virginia grew about 10,000 acres. The three States mentioned outrank all others by at least 2,000 acres. No adequate estimate can be placed on the value of this crop, as it fluctuates very decidedly, both in acreage and in price, from year to year.

Cabbage culture naturally falls under two heads: (1) The truck crop of the South and the early market-garden crop of the North, both based on early-maturing sorts, and (2) the autumn crop of the farm and gardens of the North, based on the more robust-growing varieties classed as late cabbage.

Early cabbage is practically all consumed as a green vegetable. The late crop, on the other hand, is handled as a fresh vegetable, as a storage crop, and for the manufacture of sauerkraut. Cabbage is always in demand, and under present conditions it is always available, either as the product of a southern truck farm or a northern farm, garden, or storage house.

The group of cultivated plants which has been derived from the wild cabbage presents a greater diversity of form than that derived from any other single ancestral type.

Wild cabbage is a robust-growing broad-leaved plant enjoying the low, moist areas near the seacoast of southern Europe. The most closely allied form now in cultivation is the collard. The wide variation in the group is illustrated by the diversity of form shown in collards, kale, tree cabbage, marrow kale, cauliflower, and Brussels sprouts. It is almost beyond the bounds of reason to believe that all these forms have been derived from a common parentage, yet such is the fact.

CABBAGE AS A TRUCK CROP.

INFLUENCE OF CLIMATE.

The cultivation of cabbage as a truck crop at the South is so different from its culture at the North that this industry is one of the most interesting of the truck-crop group.

The winters of the Atlantic seaboard from Baltimore southward are comparatively mild. Cabbage grown from seed sown in September and transplanted to the open in December can be successfully carried through the winter by planting it on the side of a ridge so as to protect it from the prevailing winds. The ridge should be at right angles to the direction of the prevailing winds, if possible, unless this would necessitate placing the plants on the north side of the ridge.

The dates of seed sowing and transplanting to the field, the direction of the ridges, and the position of the plants on the ridge, are varied to conform to the conditions in the various localities. Near Baltimore, for instance, it is imperative that the plants be set the last of November on the side of the ridge, while in the Charleston district of South Carolina the planting season is later (early in December) and the plants may be set on top of the ridge instead of on the side.

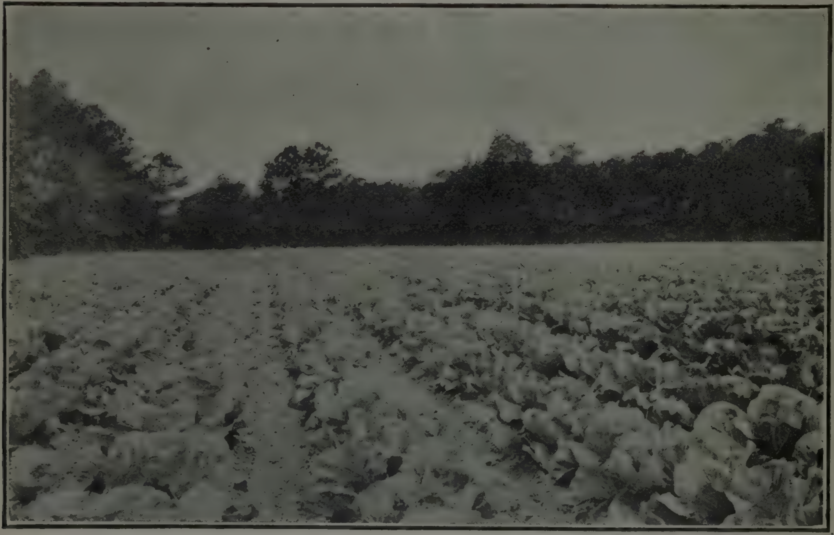

FIG. 1.—A good field of early cabbage in the trucking section.

Most varieties of cabbage are hardy enough to live through the winter and at the same time make considerable root growth. Cabbage which has safely passed the winter under such conditions is prepared to make rapid growth on the arrival of congenial weather in the spring. As a result, cabbage so handled is ready for market early in the season, as is indicated by figure 1.

SOIL.

While cabbage will thrive upon a wide diversity of soil types, the soil which is usually selected for truck-farm operations is what gardeners call a "quick soil"—one composed of sand with a small percentage of clay. Much of the soil of the important trucking region of the Atlantic seaboard consists of the type denominated "Norfolk sand" or "Norfolk sandy loam." This soil can not be said to be ideal for cabbage, but suits it better than would the more retentive soils because of the season at which the crop is desired. Quick growth and development is a prime requirement in all truck-farming operations. Sandy soils, because they contribute to this end and because they can be cultivated at a season when it would be impossible to handle heavy soils, are almost universally chosen for truck-farming operations.

FERTILIZERS.

The soil for cabbage should, if possible, be an area upon which a green crop or a liberal application of stable manure can be turned under previous to planting in the fall. If fertilizers are used at planting time they should carry normal quantities of phosphoric acid and potash, but only a small percentage of nitrogen. There are two reasons for this: (1) A slow vegetative growth is desired at this season in order that the plant may be prepared to withstand the most trying period of the winter; (2) nitrogen, if applied liberally when the plant is small, will, because of its solubility, be lost, as the plant will not be able to use it as fast as it becomes available. Then, too, a liberal amount of nitrogen available at this period would induce a rapid, succulent growth which would make the plants tender and unfit them for passing the severe weather of the winter.

A satisfactory fertilizer for the planting season will carry 1½ or 2 per cent of nitrogen, 6 to 8 per cent of phosphoric acid, and about 10 per cent of potash. This fertilizer should be scattered broadcast over the area at the rate of 1,000 to 1,500 pounds per acre.

At the approach of the growing season the development of the cabbage should be stimulated by applying a side dressing of 150 to 200 pounds of a fertilizer carrying a high percentage of nitrate of soda or sulphate of ammonia with little or no phosphoric acid or potash in it.

Experience has proved that it is best to induce only a moderate growth in the cabbage immediately after planting, so that the leaves shall be firm and tough to resist any severe changes of temperature which may occur during the winter months. The nitrogenous fertilizer, therefore, is largely eliminated from the application made at planting time and reserved until the opening of the true growing season, which will vary in different localities according to the latitude in which the work is being conducted.

While this plan of applying the fertilizer to the growing crop is of utmost importance, it should not be forgotten that potash is the important element in a fertilizer for cabbage.

SEED.

In no truck crop does the character of the seed count for more than in cabbage. It is very essential that the crop come to marketable maturity early, that the heads be uniform in size and character, and that they mature so that the whole crop can be harvested at two cuttings. The small saving made by the purchase of cheap or inferior seed is usually paid for a hundred times over in the lessened value of the crop. A grower can not afford to risk his crop for so small a saving. The best seed that can be obtained is none too good, and anything short of this is not good business. Without highly viable seed of a good strain, true to type, the best results can not be expected.

THE CROP IN THE SEED BED.

Cabbage plants for a truck crop are grown in large beds prepared in the open field. The seed beds should be prepared in a new place each year. The area should be one on which neither a crop nor a seed bed of cabbage has been grown for six or seven years, to safeguard the plants against disease. The seed is usually sown broadcast or in close drills in late September or early October, in order that the growing plants may be available for transplanting to the field during the last half of November or in early December, according to the location in which the work is being carried on. The seed should be sown thinly, so as to insure stocky plants.

In some localities the production of plants for transplanting purposes is an important commercial industry. A few growers in the neighborhood of Charleston, S. C., conduct a business which enables them to supply plants for transplanting purposes in carload lots. Under ordinary conditions, however, the plants for transplanting are grown by the trucker and transferred directly from the seed bed to the field.

Under normal conditions one-fourth of a pound of seed in the seed bed will supply plants for setting an acre in the field.

TRANSPLANTING TO THE FIELD.

At the time of setting the plants in the field, if transplanted by hand, they should be lifted, puddled, set with a dibble, and firmed by a second thrust of the dibble. If set by a transplanting machine the soil will be firmed by the compression wheels or firming blades of the machine. The usual practice throughout the southern trucking area is to throw up ridges at right angles to the prevailing winds, which usually means that ridges are made east and west, and on the south side of these ridges, about a third of the distance from the base to the top, the cabbage plants are set 13 to 18 inches apart. If at the time of transplanting the weather is warm and evaporation is rapid it is advisable to prune off about half the leaf area of the plants in order that evaporation may be diminished and the plant receive less check than it otherwise would.

CULTIVATION.

At the season of the year following transplanting, little cultivation will be necessary, as weeds will grow slowly if at all.

Cultivation can therefore be deferred until the active growing period in the spring. Care should be taken, however, to prevent weed growth which shall in any way interfere with the development of the young cabbage plants. After the side dressing of fertilizer in the spring, cultivation will tend to bring the soil to a more nearly level condition.

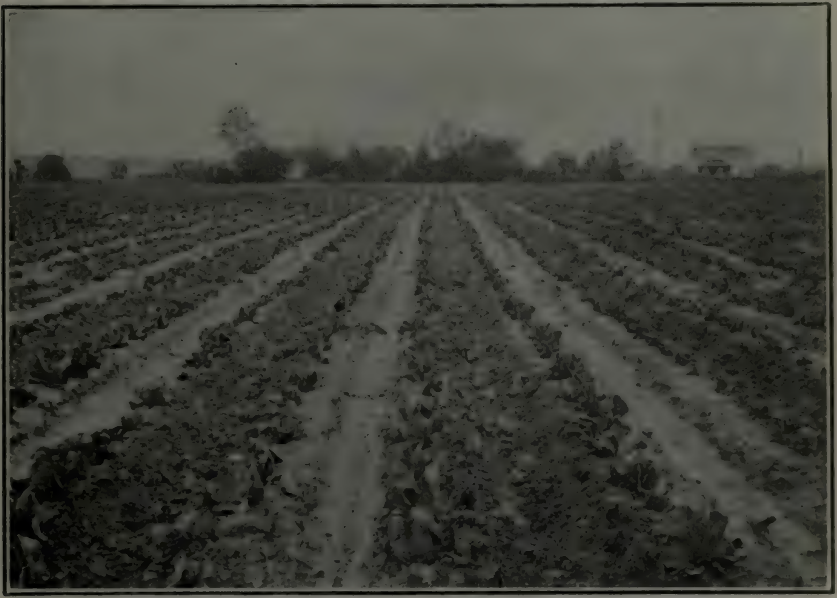

FIG. 2.—A field of cabbage, showing the spring application of fertilizer to each alternate "middle."

The side dressing of fertilizer is applied, as shown in figure 2, to each alternate "middle," and the distributers are so constructed that the fertilizer is applied to two rows of plants at one operation.

ENEMIES.

In the trucking region important enemies of the cabbage are the harlequin cabbage bug, which sometimes causes considerable damage to the plant beds in the fall; the cabbage worms, which in some instances cause considerable loss; and the cabbage "louse."

The harlequin cabbage bug.—The most effective means of controlling the harlequin cabbage bug are: (1) Careful cultural methods, which must be interpreted to mean not only good cultivation but the gathering and removal of all cabbage refuse from the field in the autumn; (2) the use of trap or decoy crops like mustard upon which the insects gather and where they can be sprayed with pure kerosene to destroy them; (3) gathering of the adult insects and the destruction of the eggs by hand; and (4) spraying the insects after or during molting with strong kerosene emulsion, or whale-oil soap at the rate of 1 pound to 8 gallons of water.[1]

Cabbage worms.—The imported cabbage worm and some other species of cabbage worms can be effectually controlled by the use of (1) Paris green at the rate of 1 pound to 50 gallons of water or (2) arsenate of lead at the rate of 4 pounds to 50 gallons of water sprayed on the young plants before the heads are well formed. This treatment should be repeated from time to time as required in order to protect the plants. Where a few plants are to be treated insect powder or pyrethrum is sometimes employed for the control of the insect by dusting it upon the plants.[2]

The cabbage aphis.—Cabbage aphides or "lice" are controlled by the use of contact insecticides such as kerosene emulsion or whale-oil soap or other soaps.

Kerosene-soap emulsion is prepared by combining 2 gallons of kerosene, one-half pound of whale-oil soap, or 1 quart of soft soap with 1 gallon of water. The soap is dissolved in boiling water and then poured while still boiling hot (away from the fire) into the kerosene. The mixture is then churned rapidly for about five minutes, pumping the liquid back upon itself by means of a force pump and direct-discharge nozzle throwing a strong stream. At the end of this time the mixture will have become of the consistency of thick cream. Properly prepared, an emulsion will keep almost indefinitely, and should be diluted only as needed for use. For most species of aphides the staple emulsion should be diluted with from 10 to 20 parts of water. In the preparation of kerosene emulsion a force pump is a necessity, since if not made according to directions a perfect emulsion is not formed.[3]

DISEASES.

Among the field troubles to which the cabbage is subject none is of greater economic importance than clubroot. This disease is peculiar in its method of attack and in the way in which it perpetuates itself. The chief danger with this disease arises from the fact that either the seed bed or the field may be infected and thus contaminate the crop. There is a danger then in purchasing plants. Infected plants purchased from a clubroot seed bed might be the means of contaminating one's cabbage land with the disease. Clubroot is a persistent malady. It will remain in the soil for five to seven years.

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[1] See Circular No. 103 of the Bureau of Entomology.

[2] See Circular No. 60 of the Bureau of Entomology.

[3] See Circular No. 80 of the Bureau of Entomology.

Land so infected should not be used for cabbage, turnips, rape, mustard, or any other plant of the cabbage family. The rotation of crops to the exclusion of all cabbage-like plants for a term of years is the only safe way of ridding the land of the disease. This applies with equal force to both seed bed and field.

Cabbage plants should never be grown in a seed bed from which plants showing clubroot have been taken, and a field producing cabbage with clubroot should not be replanted in cabbage for at least seven years. This indicates the importance of using every known precaution against the introduction of this disease. There is no satisfactory remedy known except the following "Don'ts":

(1) Don't sow cabbage seed on soil infected with clubroot.

(2) Don't plant plants grown in a clubroot infected seed bed.

(3) Don't use manure containing roots of cabbage infected with clubroot on ground intended for the culture of cabbage or any of its close relatives.

(4) Don't plant cabbage on an infected field within six or seven years after a diseased crop has been harvested.

(5) Don't grow turnips, rape, mustard, or other cabbage-like plants on clubroot infected soil unless you wish to perpetuate the disease.

Among the diseases which are at the present time causing considerable annoyance to cabbage growers is one of a physiological nature which has been brought about by improper handling of the soil. This trouble, it is believed, is chiefly due to the fact that excessive quantities of mineral fertilizers have been used in a system of farming which has not provided a proper rotation. The result is that the organic matter, which is naturally very low in these soils, has been used up and is not present in sufficient quantity to counteract or neutralize the effect of the mineral fertilizers. The result is that the plants are practically starved to death in the presence of an abundant food supply on account of the fact that it is not presented in the proper form. Investigations now under way in the Bureau of Plant Industry clearly indicate this to be the case, and from what we know of the value of organic matter, such as stable manure and green crops turned under in other agricultural operations, it is reasonable to suppose that the benefits which have come from proper crop rotation in other localities will be equally as great in the trucking region.

HARVESTING.

Cabbage which is grown as a truck crop is harvested as soon as it has attained sufficient size to be placed upon the market, regardless of its stage of maturity. The first shipments of cabbage from the trucking regions consist of very small, immature heads, often with many loose leaves upon them. As the season advances, the quality of the product improves until the heads are very closely trimmed and carefully packed. The customary practice is to drive a horse and cart in charge of a gang of harvesters across the field. Each man follows two or three rows, according to the stage of development of the cabbage, with a strong knife cuts all sufficiently developed heads from the rows as he passes, and tosses them into the cart, as shown in figure 3. The harvested heads are packed either in crates or in barrels according to the locality in which they are grown. Cabbages from the Florida and Charleston region are largely shipped in crates similar to those shown in figure 4, while cabbages from the Norfolk area are extensively packed in ventilated barrels similar to those shown in figure 5, although a considerable proportion of the crop from this region is packed and shipped in crates.

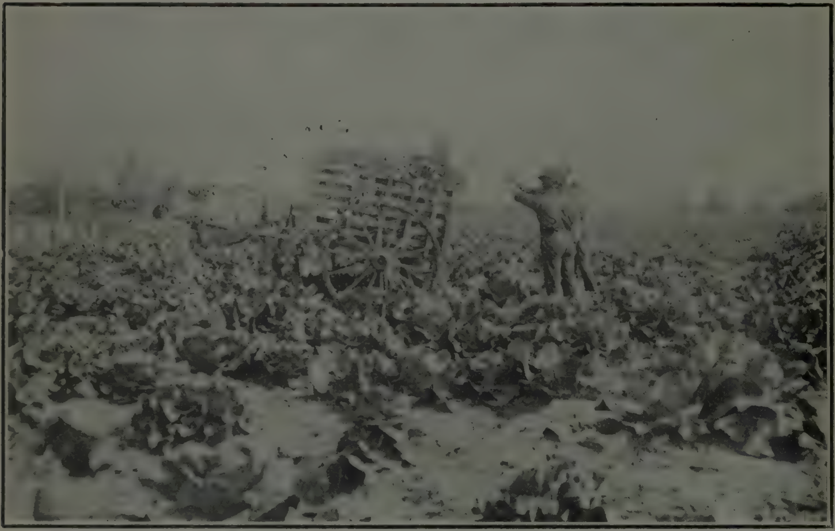

Fig. 3.—Harvesting cabbage near Portsmouth, Va.

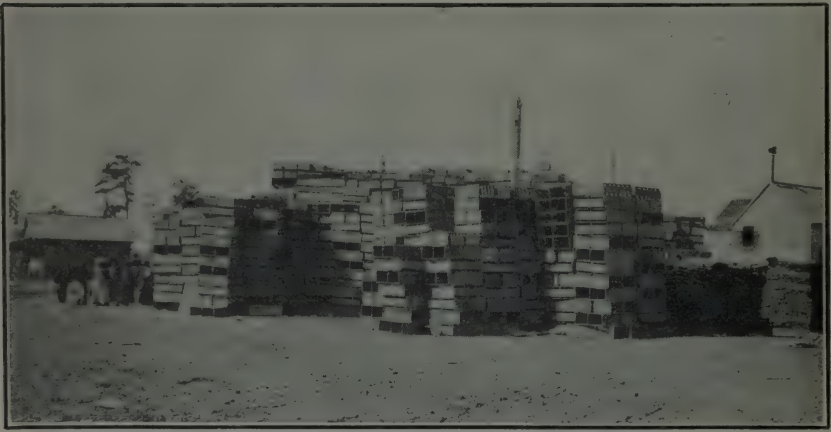

Fig. 4.—The type of cabbage crate used in the Charleston area.

VARIETIES.

The varieties of cabbage used in the trucking section are practically limited to the Wakefield type. There are two strains of this type of cabbage now extensively employed: The true Jersey Wakefield, with its small, acutely pointed tip and very firm, tender flesh of high quality, and the Charleston Wakefield, which is broader, somewhat flatter, more obtusely pointed, and slightly more angular in cross section than the Jersey type. These two strains of cabbage are well illustrated in figure 6.

MARKETING.

Cabbages from the trucking region are chiefly marketed in carload lots. Long-distance shipments of truck crops of all classes are most economically handled in this manner; in fact, it would be impossible to carry on the trucking enterprises of the country on their present scale unless it were possible to ship such commodities in carload lots.

FIG. 5.—Cabbage barrels used in the Norfolk-Portsmouth region.

The truck-crop cabbage business is at present chiefly conducted on a commission basis, although in a few sections crops are grown under contract. Owing to the perishable nature of early cabbage, it is probable that the crop will always be extensively handled on commission.

An item that should be considered by the grower of early cabbage for the northern markets is the quantity of cabbage placed in storage from the northern fields. A short crop of late cabbage at the North means good prices for early southern-grown cabbage. Low prices and heavy storage of the northern-grown fall cabbage usually mean low returns for early southern-grown cabbage. The importance to the southern truck farmer of keeping close tab on the hold-over crop of the North in order that he may not be the loser is obvious.

CABBAGE AS A MARKET-GARDEN CROP.

EXTENT OF PRODUCTION.

Cabbage is a crop which is grown by every market gardener located within wagon-hauling distance of an important center of consumption. The statistics of the distribution of the cultivation of cabbage clearly indicate the fact that this is one of the important crops grown by market gardeners. The counties near each of the important centers of population of the United States are almost universally credited with a considerable acreage of cabbage, thus showing that the gardeners of these regions have given considerable attention to the production of this crop.

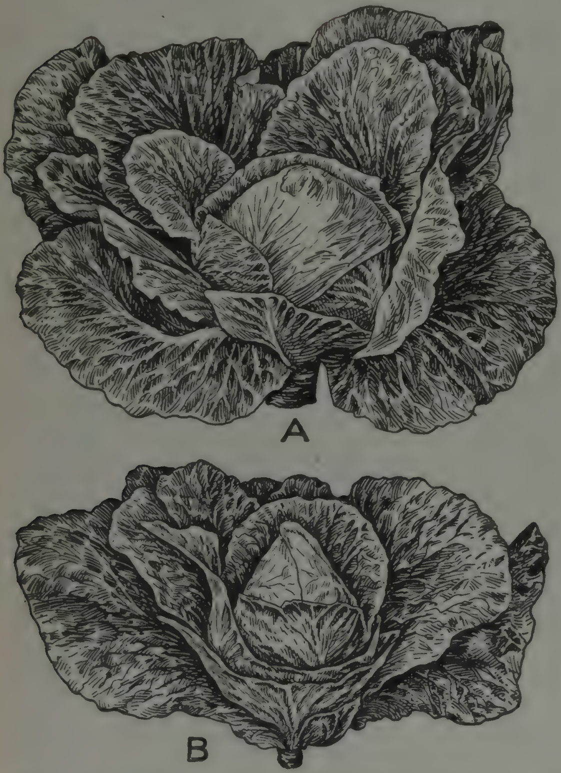

Fig. 6.—Wakefield strains of cabbage: *A*, Charleston Wakefield; *B*, Jersey Wakefield.

SOIL.

The soil for cabbage must necessarily vary in different localities. In one area it may be of an alluvial character, while in another it may be sedentary, and in still another it may be characteristic glacial drift. The fact that cabbage grows well in all these soils indicates its adaptation to a wide range of conditions. The main thing with cabbage is an abundant supply of immediately available plant food. Market gardeners rely chiefly upon stable manure for their supply of plant food. Fertilizers also form an important item in the expense of producing cabbage as a market-garden crop, the quantity used depending upon the quantity and character of the supply of stable manure. The fertilizers chiefly used carry a liberal percentage of available nitrogen in the form of nitrate of soda or sulphate of ammonia (often as much as 4 or 5 per cent), 6 to 8 per cent of phosphoric acid, and 8 to 10 per cent of potash. As a result of the wise use of manure and fertilizers the soils of the market-gardening zone around any city or large town rapidly improve in fertility and the gardener is able to grow a greater variety and larger quantities of products.

In the truck-farming area a few special crops are grown on a very extensive scale, while in market-garden regions a great many crops are grown in succession on a comparatively restricted area. Truck farming is in reality extensive market gardening, while market gardening is the most intensive form of farming. It is the practice of many market gardeners to plant coarse-growing, long-season crops far apart and to interplant one, two, or even three short-season, quick-maturing crops between them, or a quick-growing, short-season crop may be planted and between the rows a crop requiring a longer season, so that as the quick-growing crop is harvested the whole area is given up to the longer season crop. Cabbage is frequently made the basis of such a combination. Sometimes lettuce and radishes are grown between the rows of cabbage. Sometimes cabbage is planted between the rows of early beets, while late potatoes are frequently planted between the rows of early cabbage. The various combinations of such crops are too numerous to be catalogued.

YOUNG PLANTS FOR THE MARKET GARDEN.

The preparation of cabbage plants for the use of the market gardener in the North is a different matter from growing plants for use on a truck farm in the South. The market gardener at most grows only a few thousand heads. The seed for these can be sown on an area covered by a hotbed or cold-frame sash. The extra-early crop is either started in the open in September and transplanted to a cold frame as the frosty nights come on, to be protected through the winter by sash and shutters and transplanted to the open as soon as the ground can be worked in the spring, or the plants may be started in a hotbed from the 1st of February to the middle of March, depending upon the locality, and hardened off as the days grow milder by lifting the sash.

Plants grown and hardened off in this way are nearly as hardy as cold-frame wintered plants. They can with safety be transplanted to the open as soon as the condition of the soil will warrant. As a rule, hotbed-grown plants do not head as quickly as wintered plants; on the other hand there will be fewer plants that shoot to seed. The grower will therefore use the plan best adapted to his cropping system, and may employ both plans in order that the peculiarities of the seasons may be most advantageously met. In some seasons the wintered plants give best results, while other seasons seem to favor the hotbed product. The use of both plans will safeguard the crop to the greatest degree.

SETTING PLANTS IN THE FIELD.

The cabbage plants are usually set in the field in rows about 30 inches apart and 13 to 18 inches apart in the row. For the extra-early crop the Jersey Wakefield is extensively employed. A later variety may be sown in the hotbed at the same time and the plants given similar treatment, but since the late sort requires a longer season it will form a succession with the Wakefield enabling the gardener to maintain a continuous supply up to the time when he can utilize the crop grown from seed sown in April or May in the open, the plants of which are usually transplanted in the latitude of New York to the open field from June 20 to July 1. This crop provides the fall supply of cabbage for the market, and when treated as a field crop is used by the sauerkraut factories and the storage houses, and is marketed in carload lots in the southern cities and towns where extensive manufacturing enterprises are conducted.

CULTIVATION.

Among market gardeners it is a common expression that "cabbage should be hoed every day." Perhaps no other crop responds more quickly to good cultivation and an ample food supply. This is undoubtedly the explanation of the above quoted expression. In cultivating cabbage the work should be frequent and thorough, but the cultivation should not be deep. The aim should be to destroy all competing weeds and to maintain a loose, friable layer of soil about 2 inches deep over the surface of the area devoted to cabbage.

HARVESTING.

The early cabbage which is grown by the market gardener is cut, carefully trimmed, and marketed from his wagon or stall. The later crop which is harvested in the fall may not be marketed immediately, but may be stored temporarily in a cool, well-ventilated building, in which case the heads are usually cut from the stalks, carefully trimmed, and stored in small bins or on shelves. If such facilities are not available an area on a well-drained portion of the field is prepared for the storage of the cabbage. The preparation usually consists in leveling an area wide enough to allow about 5 heads of cabbage to be placed, roots up, in a continuous row or belt, as suggested in figure 7. The outer leaves are all preserved and carefully wrapped around the heads as they are placed, after which the whole is covered with a layer of straw or marsh hay, and, as the weather increases in severity, with a slight layer of earth. In the milder portions of the country this protection is employed for the whole winter. Farther north the soil layer must be increased, and where winters are severe storage houses should be used rather than this primitive method of storing.

If the crop is to be stored on a more extensive scale it may be placed on a ventilated platform and piled in long ricks, as suggested in figure 8, and then covered with rye straw and a layer of earth.

VARIETIES.

The varieties of cabbage used by market gardeners include not only the Jersey Wakefield for extra early, but a variety of the early-summer or sure-head type for the midseason, with some of the Flat Dutch sorts as the main fall crop.

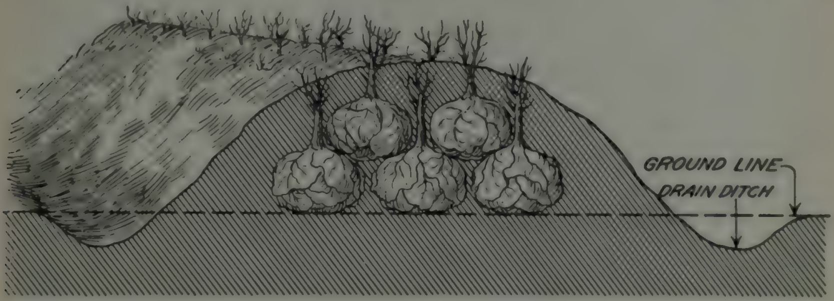

FIG. 7.—Method of storing cabbage on a small scale at the North.

CABBAGE AS A FARM CROP.

RANGE OF CULTURE.

Cabbage finds its most congenial habitat as a farm crop in the northern tier of States, including those bordering on the Great Lakes, the New England States, and to a less extent in Kentucky, Tennessee, and Missouri. New York grows almost three times the acreage of any other State as a farm crop. It is this farm crop of cabbage which finds its way to the sauerkraut factories, to the cities of both the North and South as the cool days of fall and early winter come on, and to the large storage houses distributed through New York and Wisconsin.

SOIL.

The soil upon which cabbage is most extensively grown in this region is either rich alluvial bottom land or the rich prairies of the States west of New York and Pennsylvania. Cabbage is a bulky product and usually does not sell for a very high price per ton, but the large tonnage produced per acre and the fact that it is consumed by all classes account very largely for the extensive acreage grown throughout the area of dense population.

PREPARATION OF THE LAND.

Where grown as a farm crop cabbage is used as one of the factors in a crop rotation for the farm, and may be made to occupy a portion of the clover sod turned down in the year when clover is turned under to provide for other crops. A common rotation is to use corn, followed by oats with which clover is sown. The clover is cut one season and turned under the following spring, the area being devoted to cabbage and potatoes. The clover sod is supplemented by a heavy dressing of stable manure on the portion to be devoted to cabbage. If manure is not available the necessary supply of plant food is made up by the use of a high-grade fertilizer carrying 3½ or 4 per cent of nitrogen, 6 or 8 per cent of phosphoric acid, and 8 to 10 per cent of potash, applied at the rate of 500 to 1,000 pounds to the acre.

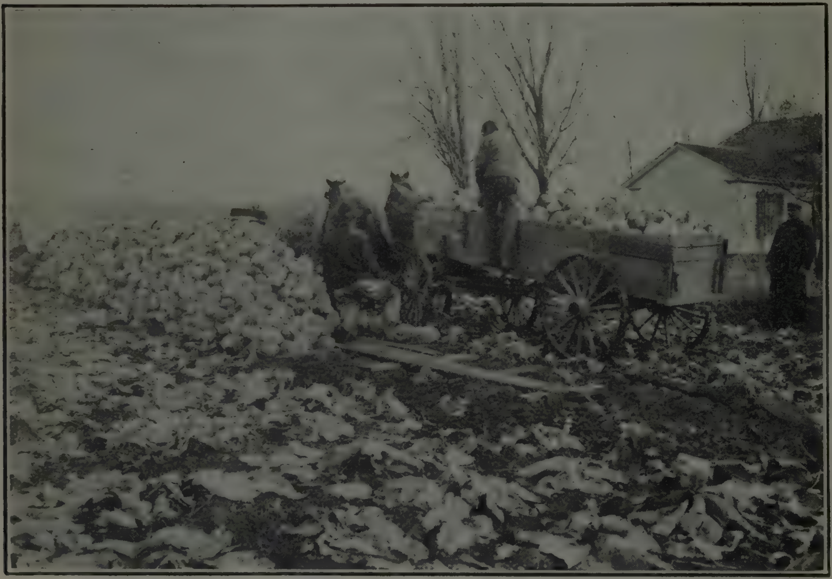

FIG. 8.—Method of piling cabbage for storage over a board-covered trench, to allow ventilation when earth is used for protection.

STARTING THE SEEDLINGS.

When cabbage is grown as a farm crop the seed bed is prepared in the open in a sheltered place. In the latitude of central New York seeds are sown in the open early in May. The young plants are kept free from weeds and should be ready to transplant to the field about June 20.

The choice of the site for the seed bed may determine the success or failure of the whole enterprise. The vigor of the plants and their freedom from disease are factors of prime importance. The seed bed should, therefore, be located only on areas known to be free from clubroot and rot organisms. Areas where cabbage has been grown or where cabbage plants have been propagated in previous years are to be avoided, as are also manures containing cabbage refuse. The manure from stalls or pigsties where cabbage has been fed is to be avoided on account of its liability to carry clubroot and rot organisms.

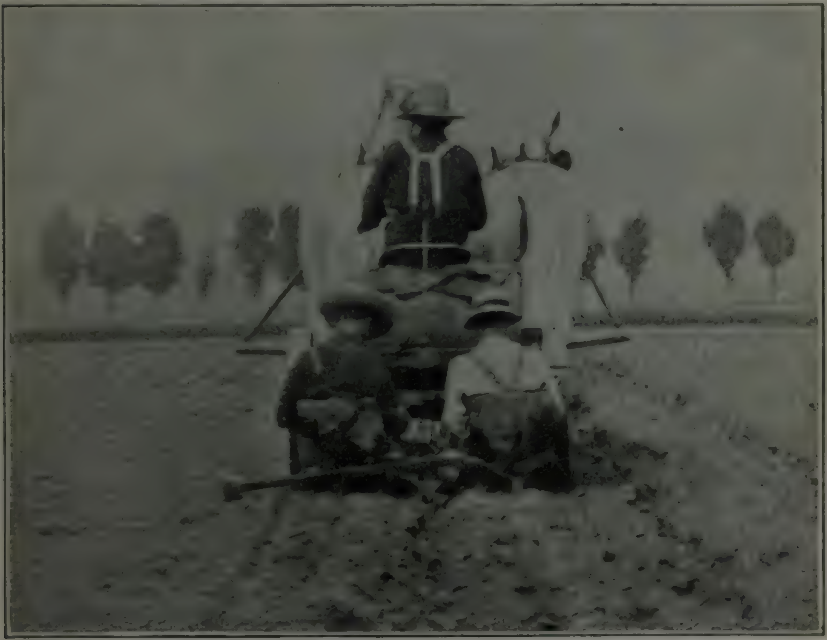

FIG. 9.—Transplanting machine in operation.

SETTING THE PLANTS IN THE FIELD.

In some localities it is customary to set the plants in check rows about 30 inches apart each way, so that they can be cultivated in both directions. In other sections the plants are set in rows one way only, and are placed 18 to 24 inches apart in the row. With the large-growing late sorts, however, 30 inches between the plants in the row is not too much space. If the transplanting is to be done by hand it will be performed by puddling the plants and setting them with a dibble. If carried on very extensively the work can, as a rule, be more economically done by utilizing one of the horsepower transplanters, such as is shown in figure 9, in which case the plants are frequently set about 20 inches apart in the row and cultivated in one direction only. Painstaking growers, however, mark the field 30 inches apart in one direction and drive the plant-setting machine at right angles to these marks, thus enabling the setters to place the plants in checkrows 30 by 36 inches apart.

This plan has the advantage of placing the plants at better intervals and permits of cultivation in both directions early in the season.

As soon as the plants have been set in the field, cultivation is started and kept up with suitable implements, depending upon the size and character of the plants, until the cultivator can no longer be run between the expanded leaves of the crop. Attention from this time on is necessary to protect the crop from insect enemies, such as the cabbage worms and the aphides or "lice." (See p. 10.)

HARVESTING.

At harvest time, whether the cabbage is to be shipped, carried to the sauerkraut factory, or stored, a wagon provided with a very deep body is driven across the field, the heads of two rows having been cut and laid at one side in advance of the team. Men accompany the team and gather the heads which have been cut, carefully trim them and gently toss them to a person in the wagon, who loads them with equal care. Heads intended for long shipment or for storage should be very carefully handled, so as not to bruise or in any way injure them. In unloading to the car or storage house the same precautions in careful handling should be observed as in gathering from the field.

VARIETIES.

The varieties which may be used for field cultivation depend upon the purpose for which the cabbage is intended. If for sauerkraut or for immediate consumption, the Flat Dutch type from American-grown seed is extensively employed in the eastern part of the United States. In the irrigated section of Colorado, in the vicinity of Greeley, where cabbage is grown for sauerkraut, a variety known as Scotch Cross is almost universally grown.

If the cabbage is intended for storage the Danish Ball Head from imported seed is almost exclusively used.

STORAGE.

The prerequisites for the successful storing of cabbages are: (1) Carefully grown and carefully handled heads of a sort well adapted for storing; (2) storage warehouses so constructed and arranged as to prevent drip from the ceiling or roof striking the stored heads; and

(3) such an arrangement and control of the ventilation and temperature of the building as to prevent the condensation of moisture on the cabbage while in storage.

The Danish Ball Head from imported seed, as has been stated, is the variety chiefly grown for storage purposes. The heads should be very carefully cut and closely trimmed so that no loose leaves get into the storage house. In hauling cabbage from the field to the storehouse, spring wagons should be used and the heads should be passed from hand to hand and never thrown into the wagon body. The same care should be observed in placing the heads in storage.

The general type of construction employed in commercial storage houses is that of a broad, low house with an alley sufficiently wide to admit a team and wagon through the center, and with the storage bins or shelves arranged on either side.

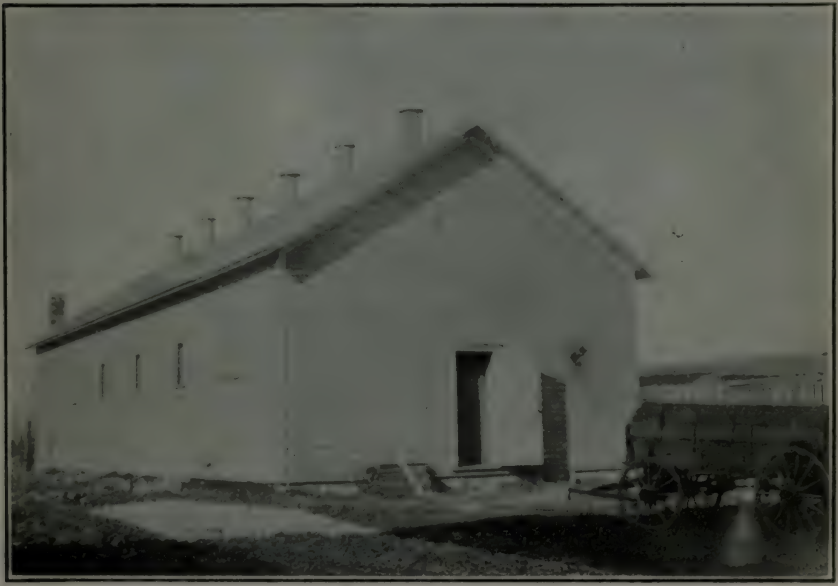

FIG. 10.—Frostproof storage house for cabbage on a New York farm.

For farm storage the type of house illustrated in figure 10 is very satisfactory. There are no walks or driveways in this house and therefore no waste space. At storage time the cabbages are received through the windows, and they may be discharged either through the windows or through the door. If the heads are to be stored in bins, the bins should be narrow and not more than 16 or 18 feet from front to back, and the heads not more than 6 or 7 feet in depth in each bin. Several bins may be placed one above another in the same section by placing a waterproof flooring between the bins, so that the drip caused by decaying cabbage or other condensation can not reach the lower bin from the one above. This plan of storage is not, in general, as satisfactory as to store the cabbage on shelves, as shown in figure 11. As is suggested in the figure, the heads may be stored in single layers or in layers two or three deep on the shelves. Precautions should be taken to provide an area way between the outside wall of the building and the storage bins or shelves.

The walls of the building should be so made as to provide a dead-air space to prevent the penetration of frost. If the walls are made of brick, two 4-inch walls could be laid up and tied by a header course, so as to provide an air space 2 or 3 inches wide between the two walls; or a solid 9-inch wall may be constructed and either a tongued and grooved wall or a lath-and-plaster wall placed on the inside by the use of furring strips. The roof should be provided with a suitable outer covering, either of shingles, of steel, or of composition, and should have an inner lining so built as to provide a dead-air space. If the inner lining is made of lumber the boards should run parallel with the rafters rather than at right angles to them, so that condensation may flow to the eaves rather than fall from each joint. Exits for warm air should be provided by ample ventilators along the ridge, provided with dampers, which can be controlled by ropes extending to the passageways. Cold air from the outside can be admitted through apertures in the foundation by means of large terra-cotta pipes

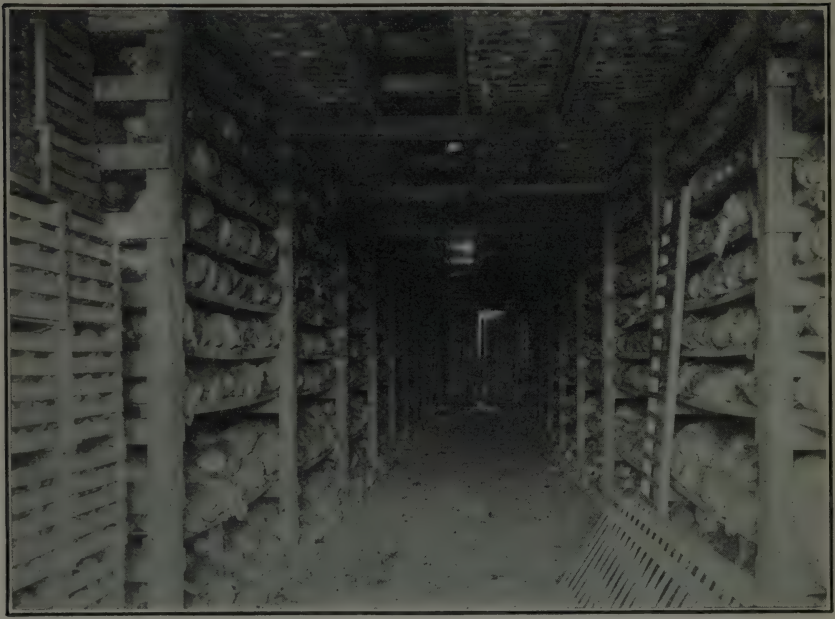

FIG. 11.—Interior arrangement of a cabbage storage house showing the method of placing the heads on the shelves.

provided with wire netting over the outer end and suitable dampers or shutters on the inside, so that the intake of air can be controlled.

The secret of success in the management of a storage warehouse is to have disease-free, well-matured, firm, carefully-handled stock grown from high-grade seed and the storage house so constructed that the temperature can be lowered and maintained as near 34° F. as possible throughout the whole storage period. This means that the greatest care must be exercised to take advantage of cool, frosty nights which occur during the storage period, and as soon as the house is filled to keep it closed during the day and open as much as possible during the night so as to get the benefit of the low night temperatures. The other extreme of too low temperature should also be provided against. During protracted cold spells the temperature inside the storage house may get dangerously low. To guard against loss from freezing, oil heaters are placed at suitable intervals in the walks and alleys to maintain the temperature above the danger point.

Storage troubles are more largely the result of careless handling and bad ventilation than of diseases. Practically all of the rotting which takes place during the storage period is the result of saprophytic organisms attacking the badly handled or slightly diseased heads under bad storage conditions. Poor cultivation, bad harvesting methods, a long haul to storage, and rough handling in unloading and storing are all to be avoided if cabbage is to be kept successfully through the storage period.

Further information as to the decay of cabbage in storage will be found in Circular No. 39 of the Bureau of Plant Industry, U. S. Department of Agriculture, entitled "The Decay of Cabbage in Storage: Its Cause and Prevention."

[A list giving the titles of all Farmers' Bulletins available for distribution will be sent free upon application to a Member of Congress or the Secretary of Agriculture.]

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Issued March 27, 1911.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 434.

THE HOME PRODUCTION OF ONION SEED AND SETS.

BY

W. R. BEATTIE,
Assistant Horticulturist, Bureau of Plant Industry.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., January 12, 1911.

Sir: I have the honor to transmit herewith a manuscript entitled "The Home Production of Onion Seed and Sets," by Mr. W. R. Beattie, Assistant Horticulturist, and to recommend that it be published as a Farmers' Bulletin.

The production of onion seed and sets is of considerable importance from both a truck-crop and farm standpoint. As the handling of these crops requires a knowledge of special methods of culture there is a constant demand for the information herein contained.

Respectfully,

Wm. A. Taylor,
Acting Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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THE HOME PRODUCTION OF ONION SEED AND SETS.[1]

INTRODUCTION.

Many of the leading onion growers of the Northern States are now raising their own supplies of seed, for by so doing they can procure a better grade than is obtainable in the general market. During the early history of onion-seed growing in this country the crop was practically all produced in small plantings. Later the production of seed fell into the hands of a few large or speculative growers. During recent years there has been a tendency to return to former conditions.

Formerly the supply of onion seed came from farmers who selected seed bulbs of a uniform type year after year and in so doing established a definite strain; these bulbs were chosen from the entire crop of marketable onions, which permitted the selection of only those of the type desired for seed. In so doing the farmers were practicing selection, all bulbs not conforming to the desired type being discarded. In commercial onion-seed growing, where the bulbs are grown exclusively for seed purposes, it would not be profitable to discard all those that do not conform to the desired type.

It is customary for growers to select very carefully the few mother bulbs necessary to produce stock seed from which to grow their commercial crop of seed. In cases where commercial seed growers are short of bulbs for seed purposes, they frequently go into the market and purchase the best obtainable to make up the deficiency. Where a farmer is producing three or four thousand bushels of onions for the market from pedigree seed, it will be a comparatively easy matter for him to select two or three hundred bushels of extra fine bulbs of the type desired for seed. Onion seed produced in this manner from selected bulbs and sold at $1.50 a pound will in the end be cheaper than seed at 40 cents a pound that has come from a miscellaneous lot of bulbs taken as they run, without selection.

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[1] For the culture of onions for the general market, see Farmers' Bulletin No. 354, entitled "Onion Culture," which will be sent free on application to the Secretary of Agriculture.

Unfortunately, the home production of onion seed is now more or less dependent upon the market price of onions the previous season. Many growers plant for seed only when they have failed to sell their crop, thus giving uncertainty and irregularity to the enterprise. There are a few farmers who plant a fairly uniform quantity of bulbs for seed each year, and who are making a decided success of the work.

Certain growers are better equipped than are others for the growing and handling of the seed, and thus are in position to supply seed for the entire community. It has been found that carefully grown seed planted in the same general locality in which it is produced will give better results than seed brought from a distance; this is especially true in northern localities, where the season of growth is short, as southern-grown seed requires a longer season for its maturity.

The production of onion sets has been confined to a few localities. Now, however, the industry is receiving more general attention. Sets may be produced under a reasonably wide range of conditions, but in order to be successful it is essential that the grower should fully understand the principles and methods involved. The production of onion seed and sets is an important phase of the general onion industry, but owing to its more local nature it is treated separately.

HOME PRODUCTION OF ONION SEED.

SELECTION AND CARE OF BULBS FOR SEED.

The bulbs, or "mother bulbs," as they are commonly called, for the production of onion seed should be grown in the same manner as those intended for marketing, except that more care should be taken throughout. Some seed growers prefer to use 6 pounds of seed to an acre for the production of seed bulbs instead of 4 pounds, as ordinarily used in growing for market, in order that the bulbs may crowd and not become too large. The planting, culture, and harvesting of the bulbs are practically the same as for first-class marketable stock.

Onion-seed growing is a two-year process and two crops are constantly to be cared for. After growing the bulbs the first summer they must be stored over winter and replanted the following spring for the production of seed. Meantime the crop for the next year's planting must be coming on in order to have a crop of seed every year.

Onion seed can not be grown profitably in all parts of the country, for various reasons. Proper soil conditions are essential; also a climate that is free from extremes of temperature and rainfall. Certain localities in the Northeastern States near the ocean, around the Great Lakes, and again on the Pacific coast are especially adapted to the production of onion seed.

The first requisite for the growing of the best seed is a clear-cut ideal of the exact shape, form, color, and general characteristics sought in the variety being grown. The second requisite is the growing of seed from bulbs of that exact type for the greatest possible number of generations.

Two selections should be made, the first to include but a small number of the very finest and most ideal bulbs from which to produce the stock seed to be used the following year for the growing of the seed bulbs, and the second to include the bulbs from which to grow the supply of seed for the market. By keeping the very best stock separate and using the product for propagation the entire strain will be gradually improved. Bulbs a trifle below the ideal market size, or about 1½ to 2 inches in diameter, are the most profitable for seed production.

CARE OF BULBS DURING WINTER.

Bulbs that are to be used for seed production should be allowed to become thoroughly ripe in the field. After pulling they should be stored in crates under a roof where they will have plenty of ventilation and be protected from sun and rain. Before freezing weather begins the onions should be graded and removed to a house where both ventilation and temperature can be controlled.

The temperature of the storage house should at no time be so low as to cause the bulbs to become frosted. A temperature of 32° F. for a short period will do no harm, but should not be allowed to continue. If the bulbs become frosted, heated, or sweated in storage they will sprout before planting time and be greatly injured for seed purposes. In general, the storage conditions should be the same as for marketable onions.

SOILS ADAPTED TO THE GROWING OF ONION SEED.

Two types of soil may be used to advantage in growing onion seed. The soil upon which the bulbs are grown from seed should be quite rich and well supplied with organic matter and moisture. Good, rich, sandy loam is best adapted to the growing of the bulbs. For the production of seed from bulbs a soil that is well drained, fertile, and of a loamy nature is desirable. It is customary to grow the bulbs the first season on rich bottom land and to grow the seed the second season on well-drained upland. Soils containing an abundance of lime, such as are suited to the successful production of wheat, are adapted to onion-seed growing. The soil should be free from weed seeds and in a good state of tilth.

The bulbs for seed growing should not be set in a soil containing large quantities of fresh stable manure or green vegetable matter, but rather in a soil where some cultivated crop, such as corn, has been grown the previous season. Commercial fertilizers containing a small percentage of nitrogen, 6 to 8 per cent of available phosphoric acid, and 6 to 8 per cent of potash can be used to advantage at a rate not exceeding 1,000 pounds to the acre.

PREPARATION OF THE SOIL AND PLANTING.

In preparing the land for setting the bulbs apply the fertilizer and reduce the soil to a good state of tilth. Then mark off the land in rows about 2½ to 3½ feet apart by means of a one-horse plow, a corn marker, or some tool that will leave a decided furrow in which to set the bulbs. In some sections the rows are placed as close as 2 feet, but this hinders cultivation.

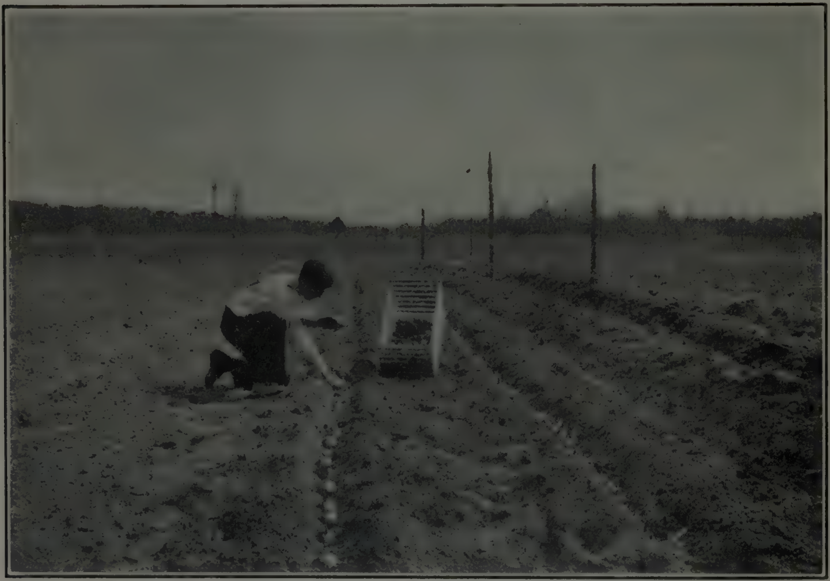

FIG. 1.—Method of setting out bulbs for seed production.

The bulbs should be placed by hand (fig. 1), root downward, from 3 to 6 inches apart, center to center, in the furrow. The usual rule is to so set the bulbs that the distance between them will be about equal to the diameter of the bulbs. The quantity of bulbs that may be set on an acre will depend largely upon their size, but may be as high as 250 bushels. Where the seed is to be employed for growing sets and overgrown sets are used as "mother" bulbs the quantity required may be as low as 50 bushels to the acre. The bulbs should be placed in the ground sufficiently deep to be entirely below the surface of the soil when covered. As growth proceeds, the soil should be drawn around the bulbs to form a support for the seed stalks.

CULTIVATION.

Shallow cultivation should be given throughout, the object being to keep the land free from weeds and the soil worked toward the plants. Very little handwork will be necessary except, perhaps, to go through after the seed heads have formed, remove the weeds, and draw the soil around the plants to hold the stalks erect and prevent the seed heads from blowing down and coming in contact with the soil.

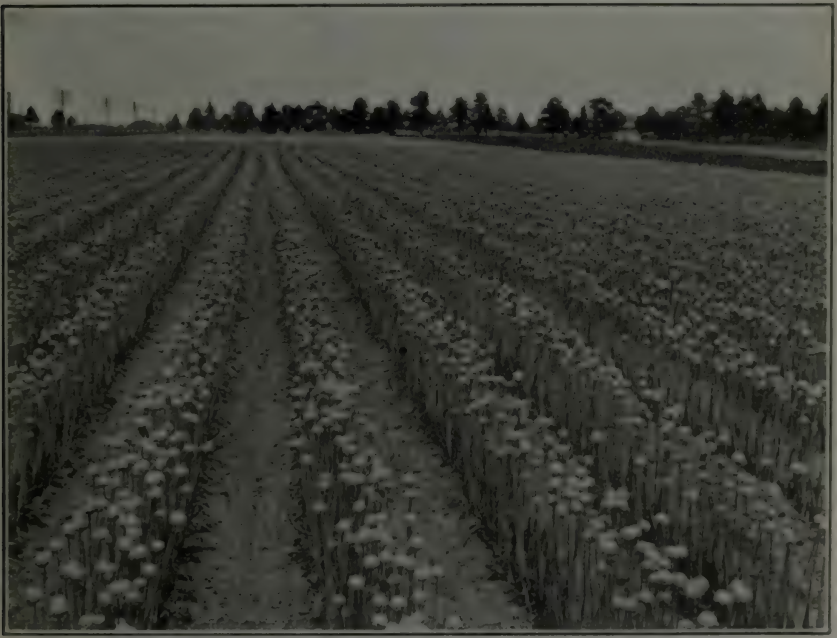

FIG. 2.—Field of onion seed a short time before harvesting.

TIME AND MANNER OF GATHERING THE SEED.

The proper time to gather the seed is when the inside of the grain has reached the dough stage. Onion seed assumes its black color very early; in fact, before it has passed the watery stage and formed milk in the grain. This change of color is no indication of ripeness and very often deceives the inexperienced grower. The heads should be harvested just before the first-formed seed begins to shatter in handling.

Figure 2 shows a field of onions a short time before the seed is ripe. In harvesting, the heads are cut by hand, with 2 to 6 inches of the stem attached, and are placed in bags for transportation to the curing sheds.

CURING THE SEED HEADS.

Any building having a tight floor and in which a free circulation of air can be maintained will serve as a curing place for onion seed. Many growers employ buildings similar to those used for curing tobacco, with the alternate vertical siding boards hinged so that they can be thrown open during good weather. In localities where rains do not occur during the curing period the seed heads are frequently dried on sheets of canvas stretched over frames or spread upon the ground.

For curing the seed in houses, wire-bottomed racks or trays placed one above the other are generally employed. As the seed is stirred from time to time during the curing process considerable of it will be shattered and fall upon the tray below or finally upon the floor. The main essentials in the curing of onion seed are to spread the heads very thinly, not over two heads in depth, and to give free ventilation. Even at a depth of 3 inches in the trays it will be necessary to stir them very often, especially during damp weather.

THRASHING AND CLEANING THE SEED.

The date for gathering the seed depends upon the locality and climate, but as a rule this will be about midsummer or not later than August 15. The thrashing and cleaning of the seed are often deferred until quite late in the autumn, except where the curing is done in the open air. Where large quantities of seed are produced the thrashing is done with machines similar to regular grain thrashers, but when grown on a small scale the seed is removed by beating with a flail.

After the seed has been thrashed, there is still considerable danger of its heating or molding if left in too great bulk. The usual practice is to run it through a fanning mill to remove the dust and small particles of the heads or chaff that are broken up in thrashing. In former years the method of cleaning was to place the seed in a tank of water, the heavy seed settling to the bottom of the tank, while the chaff and lighter portions could be floated off. This process is no longer used to any great extent, owing to the improvement in cleaning machinery, and the danger of injuring the seed by the water. After the seed is fanned and most of the foreign matter removed, it should be spread thinly on the floor or canvas and stirred from time to time. About the only test that can be applied in order to detect moisture in the seed is that of feeling it with the hand, and anyone experienced in the handling of seed will soon become expert at determining when it is safe to bag it ready for storage or shipment.

YIELD OF ONION SEED TO AN ACRE.

The quantity of onion seed that can be grown on an acre depends on several conditions. In the first place this will be determined largely by the size of the bulbs that are planted. In the onion-set districts, where the seed with which to produce the sets is locally grown from overgrown sets, the quantity of seed is generally from 10 to 12 pounds to the bushel of bulbs planted. This seed, however, is not suitable for the production of standard market onions, and can be used for set growing only. In the production of seed from standard mother bulbs the yield is generally from 3 to 4 pounds of seed for every bushel of bulbs planted. This has been much higher in many cases, but 3½ pounds is generally considered satisfactory. The yield of seed as a rule will be about 400 pounds to the acre, although as high as 800 or even 1,000 pounds have been secured.

The price per pound paid for the seed varies according to the quality, variety, and market demands. For first-class high-grade seed from specially selected bulbs of desirable types the growers frequently receive as much as $1.25 a pound, but for the general crop produced from bulbs not specially selected, which must be sold in competition with the great mass of seed produced by large growers, the price is generally not more than 40 or 50 cents a pound.

When the cost of growing the bulbs, together with the preparation of the land, the keeping of the bulbs over winter, the necessity of handling them a large number of times, and the occupying of the land for two seasons, is considered, it will be readily seen there is not a great profit in growing onion seed. However, there are quite a number of farmers who each year plant 2 or 3 acres to bulbs for seed, and have for sale anywhere from 1,000 to 1,500 pounds of very choice seed. In many cases this represents the money crop of the farm. The extent to which this enterprise could be conducted with profit is doubtless limited, but the demand for high-grade seed of a distinct type is increasing each year. Anyone contemplating the growing of onion seed should carefully study local conditions, and then operate in a small way until the necessary practices are understood.

PRODUCTION OF SEED FOR ONION-SET GROWING.

Frequently the seed for onion-set growing is produced from bulbs selected from the sets themselves; in other words, the bulbs or mother bulbs are the overgrown sets. Near Louisville, Ky., the onion-set growers select the oversized bulbs and store them over winter. In the spring they send them to farmers in the hill country and have their supply of seed grown on bluegrass land which has not been heavily manured. In this way they are able to keep their onion seed free from disease and secure a higher vitality than if the seed were grown on the same land where the bulbs were produced.

Owing to the great quantity of seed employed in set growing it is desirable to secure it cheaply, and the bulbs selected from the sets, being small, will produce a larger quantity of seed per bushel from mother bulbs than when grown in the usual manner. The stock seed bulbs should, however, be well matured, small necked, uniform in size, and selected according to an ideal shape. Onion seed from undersized bulbs is not so desirable, even for set growing, as that from standard bulbs.

After a crop of onion seed has been gathered it is the usual custom to plow up the bulbs and devote the land to some other crop. If the old bulbs are allowed to remain in the soil through the winter, especially if given slight protection, they will produce a small crop of seed the second season. This practice is not recommended except under special conditions where the land is not valuable or where it is particularly desirable to secure an additional quantity of seed from the bulbs.

CARE OF ONION SEED.

The length of time that onion seed will retain its vitality depends largely upon maturity and climatic conditions. Well-matured seed will always keep better than poorly ripened and inferior seed. Under ordinary conditions onion seed loses its vitality very rapidly after the second year, especially if stored in a damp climate. It will often pay to ship the seed to a dry climate for storage.

PRODUCTION OF ONION SETS.

CLIMATE AND SOILS ADAPTED TO ONION-SET GROWING.

The term "set," as applied to the onion, indicates a small, undersized bulb which, when replanted in the ground, will produce a large onion. This method of producing onions is perhaps the oldest and now the most universally employed for the growing of small areas of onions in the garden and where an early crop is desired. The common method of producing sets is to plant a large quantity of seed on a small area of rather rich land and thus procure a great number of bulbs that are undersized, owing to crowding and lack of plant food. The greater number of these bulbs do not attain sufficient size or maturity to produce seed the following season and are really plants in which the process of growth has been arrested.

In the United States the onion-set industry is largely confined to a few areas. The crop is extensively grown near Louisville, Ky., Chillicothe, Ohio, and Chicago, Ill., in the Platte River Valley of Nebraska, in southwestern New Jersey, and in southern California. The entire area devoted to this enterprise in these localities is estimated at from 2,500 to 3,000 acres. The yield to the acre varies with the locality, but will average about 300 bushels. The market for onion sets is found throughout the entire country, the greater portion being disposed of in small quantities.

The climatic conditions governing the production of onion sets are practically the same as those for standard onions, although it is not necessary to plant quite so early in the spring. Onion sets can undoubtedly be grown in any part of the Northern States where suitable soil conditions can be obtained. The soil adapted to onion-set culture is as a rule about the same as that required for the growing of large onions, except that the land should not be so rich.

In the Louisville district the soil is a clay loam, containing plenty of lime. This soil, by the use of fertilizer, will yield 250 to 350 bushels of mature unions and will produce an equal quantity of sets, but the fertilizer requirements for the latter are not so great. This land is underlain at a depth varying from 18 inches to 10 or 12 feet by limestone, and is a natural bluegrass soil, retentive of moisture, and comparatively free from weeds.

In the vicinity of Chillicothe, Ohio, the soil is a river-bottom loam, being principally the washings from the hills. This soil contains occasional small beds of gravel, but owing to its silty nature it is retentive of moisture and easily cultivated.

In the Chicago area we find a variation in soil texture. In the vicinity of South Chicago, the area devoted to onion-set growing was formerly a sewage-disposal farm and is laid off in regular level beds. This soil is of a sandy, loamy nature and is very similar to the river-bottom lands at Chillicothe. Northwest of Chicago the soil is a more gravelly loam, although in some places it is of a river-bottom or silty nature.

In southwestern New Jersey the soil is a sandy loam, not unlike the Norfolk sandy loam, although it contains more or less gravel, and in places the clay approaches the surface.

It will be seen that onion sets can be grown on any land that is adapted to general truck crops, the main essential being freedom from weeds and a reasonably high state of tillage.

PREPARATION OF THE SOIL.

In preparing the land for onion-set growing the work should be performed in practically the same manner as for regular crops of onions. The plowing need be only moderately deep, but the soil must be brought to a smooth, fine surface, suitable for the proper sowing of the seed by means of hand drills. The tools generally employed for this purpose are the plow, disk harrow, roller, smoothing harrow, and sometimes a pull or drag made of scantlings or planks. A harrow of the type shown in figure 3 is adapted to the final preparation before planting.

On some land onion sets have been grown continuously year after year without any appreciably injurious results. In other localities it has been found necessary to adopt a crop-rotation system, and this is advisable wherever the quantity of available land is sufficient. A rotation including corn, Irish potatoes, onion sets, and clover will be found quite satisfactory.

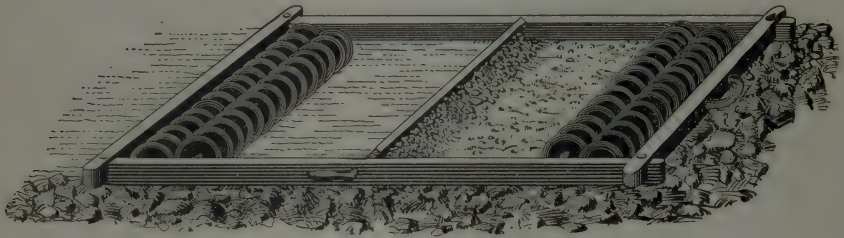

FIG. 3.—Harrow for leveling soil for planting seed.

FERTILIZERS.

In preparing the land for growing onion sets large quantities of barnyard manure should not be applied immediately before planting. If barnyard manure is to be employed it should be used the previous season on some other crop in order that it may become fully incorporated with the soil and in a measure subdued. Commercial fertilizers may be employed profitably in moderate quantities, say 600 to 1,200 pounds to the acre, and should be broadcasted at the time of fitting the land. This fertilizer should contain about 4 or 5 per cent of nitrogen, 6 or 8 per cent of available phosphoric acid, and 8 or 10 per cent of potash.

SOWING THE SEED.

As the essential feature of growing onion sets is the crowding together of the plants in the rows, a large quantity of seed is required to plant an acre. The quantity of seed required varies with the different localities. In the vicinity of Louisville, Ky., from 55 to 60 pounds to the acre are sown; Chillicothe, Ohio, 40 to 50 pounds; Chicago, 55 to 120 pounds; while in New Jersey as low as 25 pounds to the acre are used.

The drills employed for seeding are, as a rule, the hand seeders usually found upon the market used for sowing seed of all small truck crops. In some localities, however, special seeders have been designed in order to distribute the seed in a particular manner. Near Chillicothe, Ohio, many of the growers employ a drill having five small teeth similar to the shoes of an ordinary grain drill, but on a very small scale. (See fig. 4.)

These seeders distribute the seed in five little drills about an inch apart, making a broad belt of five rows. Another method is to place a funnel-shaped spreader on the under part of the drill, which scatters the seed over an area of 3 or 4 inches in width.

DISTANCES TO PLANT AND QUANTITY OF SEED REQUIRED.

The distance between the rows ranges from 7 to 14 inches, but varies with the method of sowing. The larger yields are obtained by sowing in single drills about 9 inches between the rows and using 65 to 85 pounds of seed to the acre. The majority of growers endeavor to sow their onion seed as early as the land can be put in first-class condition. Formerly the seeds for sets were not sown until late in the season, but it has been found that larger yields of sets can be obtained and that the sets will ripen better if the seed is sown early.

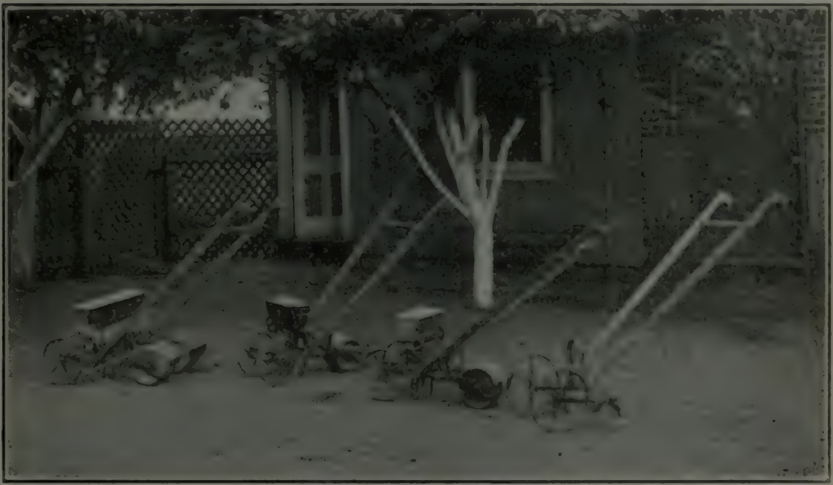

FIG. 4.—Special tools for planting and cultivating onion sets.

The New Jersey growers have found it more profitable to grow a sort of mixed crop, including all sizes from sets to marketable onions. A smaller quantity of seed is employed per acre, but, on the other hand, the method of growing is somewhat different, and a larger percentage of overgrown bulbs is secured. Those that are below standard size are sold as "boilers" or "stewers," "picklers," and "sets."

By using about 25 pounds of first-class seed to the acre and planting in rows 24 inches apart these growers are enabled to employ horse culture, and succeed in growing about 300 bushels of all sizes to the acre. This method of planting does not greatly decrease the yield and at the same time reduces the cost of cultivation.

CULTIVATION.

As a rule onion seed will germinate and the plants appear above ground so that the rows can be followed within six or eight days after planting. It is desirable that the soil should be stirred frequently and that the weeds should never be given an opportunity to gain a foothold. The onion sets should be cultivated at least once every week during their growing period, and oftener if rains occur.

The tools employed are for the most part of the wheel-hoe type, of which there are a number of forms. These tools are provided with numerous attachments for cutting close to the plants, for throwing the soil away from the rows, and for leveling and working it back around them. One or two of the Chicago growers have adopted a special wheel hoe of their own design, using the front wheel of a bicycle and a pair of light-weight plow handles for the frame, to which the various types of sweeps and shovels are attached. In New Jersey horse tools are employed almost exclusively, the 14 or 15 tooth harrow-type cultivator (fig. 5) being the favorite.

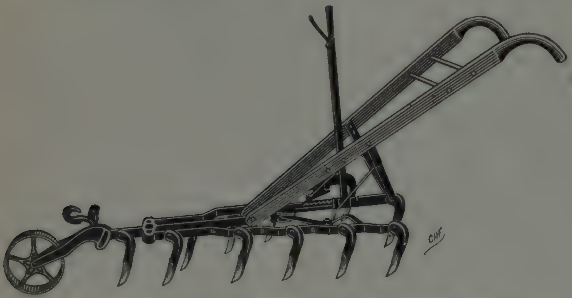

FIG. 5.—One-horse cultivator of the harrow type.

Hand weeding seems to be an essential in all localities, although this laborious process can be eliminated to some extent by proper wheel-hoe and horse cultivation. The cost of hand weeding and care of the onion-set crop may be anywhere from $10 to $50 an acre for the season. The entire cost of the cultivation of an acre of onion sets during the season should not exceed $50, and this may be reduced 50 per cent if the land is in proper condition and the work is handled at the right time. Hand weeding in most cases will be necessary twice during the growth of the crop. During rainy seasons it is often found impossible to keep certain areas clean, and when the weeds once become well established there is very little hope of saving the crop. When the sets have attained considerable growth the tops shade the ground and prevent, in a measure, the growth of weeds. After this stage has been reached very little attention will be required. In fact, the stirring of the soil should

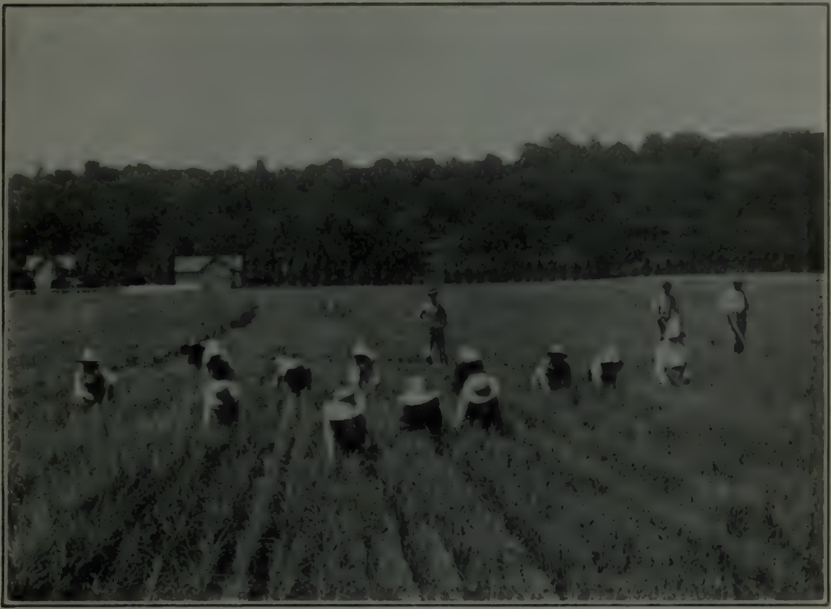

FIG. 6.—Hand weeding an onion-set field during early summer.

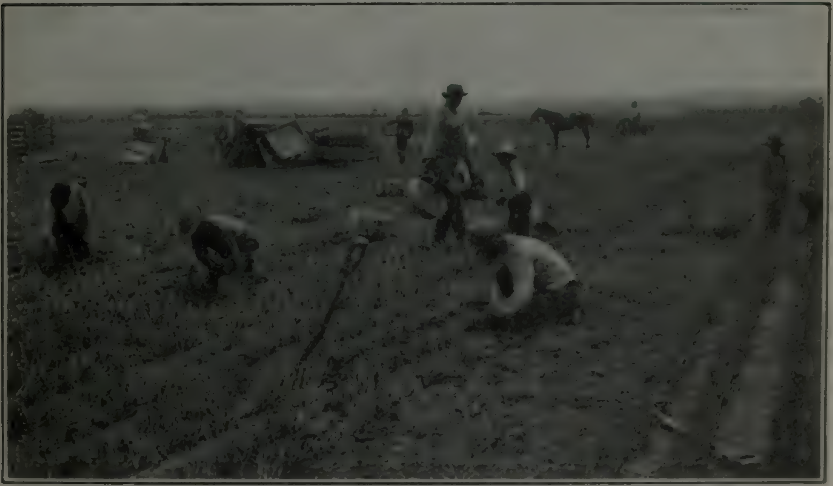

FIG. 7.—Harvesting onion sets near Louisville, Ky.

cease before the sets show any tendency to ripen. Figure 6 will give some idea of the appearance of an onion-set field at the period of its maximum development.

HARVESTING AND CURING.

The time for harvesting is just when the sets begin to ripen. This generally occurs about July 4 in southern localities, and July 20 near Chicago, or from 90 to 110 days from the date of sowing the seed. The methods of harvesting are different in the several localities. Near Louisville, Ky., the sets are allowed to become quite ripe before harvesting.

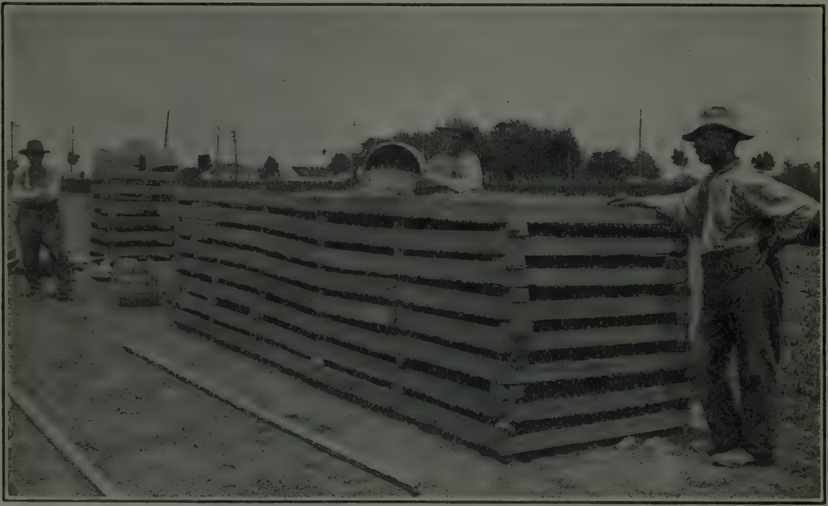

FIG. 8.—Onion sets drying on trays piled in a field.

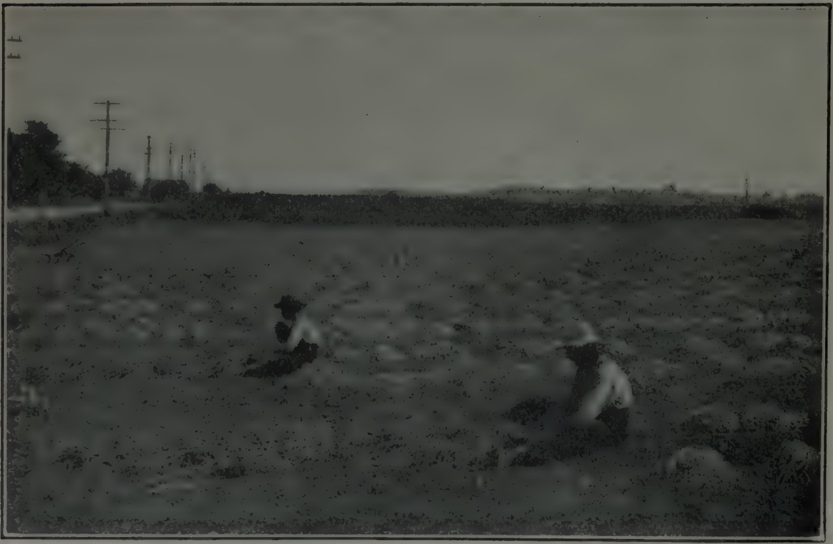

FIG. 9.—"Stacking" onion sets to cure in a field.

At harvest time, the sets are loosened from the soil by means of a cutter attached to a wheel hoe or with broad forks having 10 or 12 tines. They are then pulled by hand, as shown in figure 7, the tops twisted off by hand, and the bulbs sifted and placed upon trays to dry. These trays are piled one upon another in the field (fig. 8) with a space of 3 or 4 inches between and a temporary roof placed over them. They are allowed to remain upon these trays until quite dry and are again screened and removed to the storehouse.

Near Chillicothe, Ohio, the sets are pulled while yet quite green and stacked in the field in long narrow ridges (figs. 9 and 10), the bulbs being placed underneath so that the tops will protect them from sunlight and rain. After remaining in these ridges about two weeks, the tops are twisted off and the bulbs placed upon screens to dry. From the screens they are hauled to the warehouse where the fanning and cleaning take place.

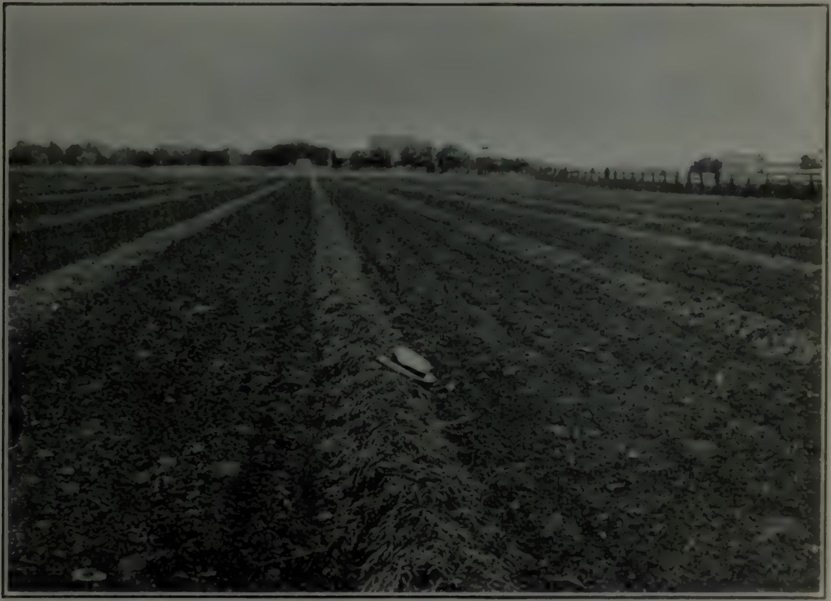

FIG. 10.—Onion sets curing in "stacks."

Near Chicago, the practice of pulling is very similar to that in the vicinity of Louisville, the tops being twisted off as the sets are removed from the soil. In New Jersey the sets are allowed to become fully ripe before being removed from the soil and are harvested and cured together with the larger bulbs, after which they are separated by screening and fanning.

After pulling it is essential that the sets be subjected to a drying process: during this process they require plenty of ventilation. This can be most easily secured by spreading the sets on trays, commonly called crates, that are provided with corner pieces extending 4 or 5 inches above the sides of the trays. As a rule these trays are constructed with 3-inch sides, about 5 feet square, with slat or wire bottoms, and hold about 3 bushels of onion sets. When the trays are piled one upon another the corner pieces provide an air space above each tray, thus securing the best possible ventilation. In the absence of corner pieces blocks of wood or broken bricks are employed, as shown in figure 8.

STORING ONION SETS.

The method of storage is essentially the same in all localities, the tray previously described being most commonly used (fig. 11). When the sets have become sufficiently dry some growers transfer them to 1-bushel crates, in which they are shipped. Onion sets are stored under conditions similar to those required for large onions, the essentials being plenty of ventilation, dryness, and a comparatively low temperature. Slight freezing will not destroy them, provided they are not disturbed while frozen. However, freezing is always injurious and has a tendency to cause them to sprout earlier in the spring. If a uniform temperature 2 or 3 degrees above freezing can be maintained it is more satisfactory than too frequent variation.

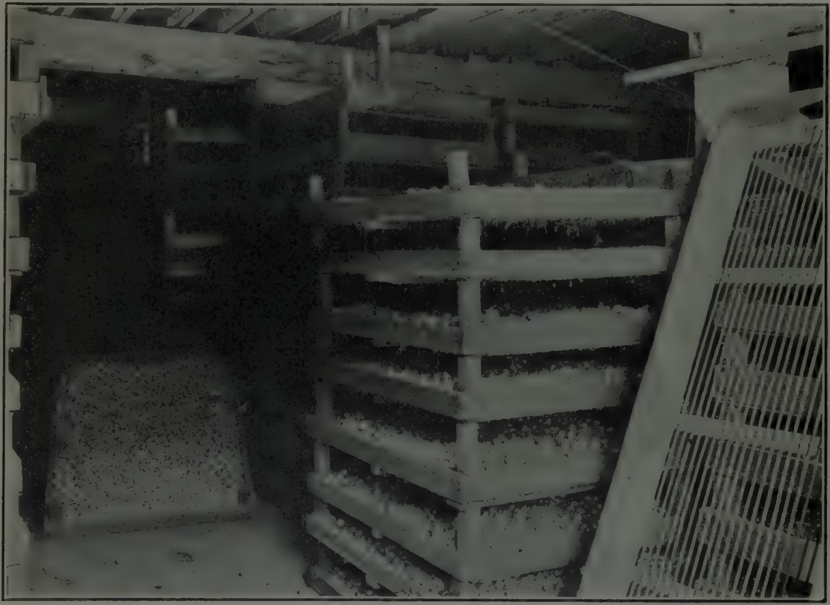

FIG. 11.—Onion sets stored on trays in a warehouse.

Some growers employ a form of open shed as a temporary storage place for the sets during the autumn months or until cold weather begins. A few growers store their crop until late winter and sell direct to seedsmen and dealers, but the majority turn their sets over to warehousemen for storage and disposal. Throughout the storage period the sets should be handled as little as possible and should be kept spread out thinly, so there will be no chance of heating. Onions in storage are constantly giving off more or less moisture and are liable to become damp and sprout if stored in too great bulk.

In preparing the sets for market they are first passed through a fanning mill which removes all loose skins, earth, or shriveled bulbs, and then over a screen which removes any bulbs that are too large for the market demands. After this they are shipped in 1-bushel crates, burlap bags, or barrels.

The crate is perhaps most desirable as a shipping package, as it protects the bulbs and allows a free circulation of the air. When shipped in bags, the sets are liable to become injured, except where they are handled in carload lots. Tight barrels are objectionable unless the sets are thoroughly cured, as there is liability to heat in the center.

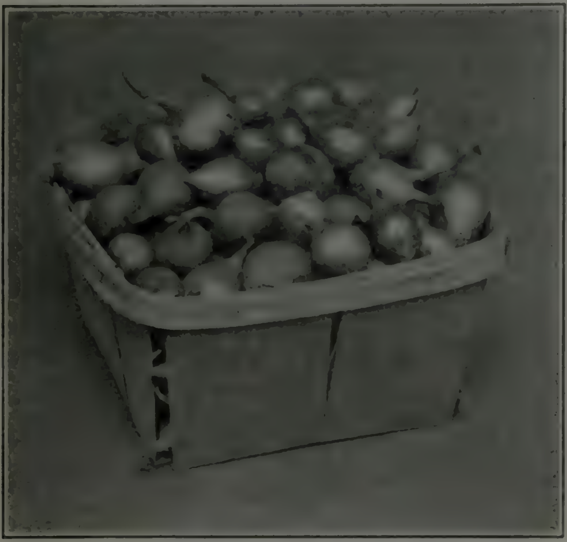

FIG. 12.—A quart of almost ideal onion sets.

PROPER SIZE OF ONION SETS.

The ideal onion set is almost globular in shape and a trifle less than half an inch in diameter. Figure 12 shows a quart of first-class onion sets. The color should be bright and the surface free from smut or spots of any kind. The term "pickler" is applied to the onion just above sets in size, or, in other words, one-half to three-fourths of an inch in diameter. The term "boiler," or "stewer," is applied to the size next larger than picklers, which are too small for sale as standard onions, or from three-fourths of an inch to 1¼ inches in diameter.

Another type of bulblet sometimes sold for propagation is that of the "top" or "tree" onion. These bulblets are formed on the top of a stalk similar to a flower stalk, and if planted will produce a fair-sized bulb. If the bulbs are allowed to remain in the soil they will throw up stalks the following season and produce bulblets for further planting. This variety is extensively used for the production of young onions which are peeled, bunched, and marketed during the early spring. The bulblets are planted closely, either in beds or in rows, during the late autumn, and the young onions will be ready for use early in the spring. In cold climates slight protection will be required in order to carry the planted bulbs safely through the winter.

VARIETIES OF ONIONS USED FOR SETS.

Seed of almost any variety of onion may be used for the production of sets, but a greater demand exists for the distinctly yellow, white, and red colors. In the trade the sets are recognized by their color rather than by actual varietal names. The demand for the yellow and the white sets is greater than for the red, and those of the globular type are generally preferred.

Onion sets are sometimes grown from left-over seed, in which case a large number of varieties may be included. In the principal set-growing districts, where the seed has been locally grown for many years, the varieties are more or less distinct from those of seedsmen's catalogues.

ENEMIES OF THE ONION.

FUNGOUS DISEASES AND INSECT PESTS.

The onion crop of the United States is by no means free from both disease and insect enemies. Some of the enemies of the onion may be controlled without much difficulty, while others, if once established, can not be eradicated by any means known at present.

Onion Smut.

The following paragraphs are extracted from a recent bulletin issued by the Ohio Agricultural Experiment Station:

> Onion smut (*Urocytis cepulae* Frost), unlike the other smuts with which we have to do, propagates itself almost indefinitely in the soil when this once becomes infested. Whenever a new crop of onions is grown from seed in this infested soil the smut attacks the young seedling onions, in whole or in part, and a very considerable loss results therefrom. If, however, onion sets are put in such soil or seedling onions that have been started under glass in healthy soil are transplanted to smut-infected soil, the smut fungus can not attack them. The explanation seems to be that the smut threads are only able to penetrate the leaves of the young, tender seedlings. Flowers of sulphur have been used to sow with the seed in infested soil, and this remedy has given but slightly inferior results to any other yet tried.

The best method has proved to be that of formaldehyde drip with seeder. The formaldehyde solution is made at the rate of 1 pound of 40 per cent formaldehyde to 25 to 33 gallons of water. This is applied with drip attachment on seed drill at rate of 125 to 150 gallons per acre for field onions. The same results can be obtained in open furrows by applying solution with sprinkler after seeds are scattered until well moistened. This formalin treatment insures the disinfection of a layer of soil near the seed and permits the germination and the early growth of the seedling onion past infection stage before the smut fungus can again occupy this soil. The gains from this treatment, both in the onion-set work and in field onions are very large, amounting to 100 to 200 per cent increase.[1]

The Maggot.

The onion maggot is often very destructive in fields that are just planted. This insect works at the roots of the young seedlings and is difficult to control.

The following methods of control have been suggested:

Carbolic-acid emulsion.—For all three forms of root maggots which we are considering, a carbolized form of kerosene emulsion is effective. This is prepared by adding to 1 pound of soap boiled in 1 gallon of water one-half gallon of crude carbolic acid and diluting the whole with from 35 to 50 parts of water. This mixture is applied about the stalks of the plants affected. It is best to use it a day or two after the plants are up or are transplanted, and repeat every week or 10 days until about the third week in May in the North. Farther south these applications must be made earlier in the season.

The use of mineral fertilizers.—Mineral fertilizers are useful as deterrents, particularly when employed just before or after a shower has thoroughly wet the ground. The principal fertilizers for this purpose are kainit, nitrate of soda, and sulphate or chlorid of potash. They may be used as top dressings before planting, or, if not employed until afterwards, they should be applied as nearly as possible to the roots, the earth being turned away from the plants for this purpose. These fertilizers possess the advantage of acting also as a stimulant to plant growth, thereby facilitating recuperation from root-maggot attack.

Danger from use of organic fertilizers.—Stable manure and organic fertilizers are apt to induce infestation, since the species under consideration is well known to develop in excrement and other decomposing material. Numerous instances of this have come to the writer's knowledge during recent years. It is advisable, therefore, to avoid the use of manure, rotted leaves, or other organic fertilizers, and to avoid planting in fields in which there have been infested or diseased plants.[2]

The Thrips.

The onion thrips belongs to the class of sucking insects, attacking the leaves and causing them first to assume a dull-gray or dirty appearance and afterwards to turn brown and die. This insect has proved very destructive, especially throughout the Southern States.

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[1] Ohio Agricultural Experiment Station Bulletin No. 214.

[2] Circular No. 63, Bureau of Entomology, U. S. Dept. of Agriculture.

and is now becoming quite a serious pest in the Bermuda-onion district of Texas. It is noticeable that insects of this character generally attack crops that are grown upon poor soils, that are late planted, and where the cultivation is neglected.

The remedies to be employed for the onion thrips are varied. Kerosene emulsion is of less value than for many other sucking insects; whale-oil soap is one of the standard remedies, and some of the tobacco or nicotine preparations have recently been found useful.

CONCLUSIONS.

There is nothing difficult in the production of either onion sets or seed and one or both may be undertaken as a side issue with other lines of farming. The work of caring for the crops may be done largely by women and children where it is desirable to provide work of this nature for them.

No large profit can be obtained from the production of either onion seed or sets, and the greater profits are obtainable from comparatively small plantings. On a considerable portion of the land devoted to onion-set raising the yield is less than 300 bushels to the acre. Allowing for the cost of seed, fertilizers, cultivation, harvesting, and handling, the net returns are not large, especially when sets bring only 50 or 60 cents a bushel.

The method of growing white onion sets followed by the New Jersey growers seems to be the most profitable, as the sets are simply a by-product of the onion crop, the main object being to secure a large yield of small, white onions, known as "picklers," which bring a high price in most of our markets.

[A list giving the titles of all Farmers' Bulletins available for distribution will be sent free upon application to a Member of Congress or the Secretary of Agriculture.]

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Issued March 17, 1911.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 435.

Experiment Station Work,

LXII.

Compiled from the Publications of the Agricultural Experiment Stations.

WATER REQUIRED FOR CROPS.
BURNING LIME ON THE FARM.
TOMATOES FOR CANNING.
LIME SULPHUR AS A FUNGICIDE.
MARKET CLASSES AND GRADES OF MEAT.
LICE ON POULTRY.
NEUFCHATEL CHEESE.

JANUARY, 1911.

PREPARED IN THE OFFICE OF EXPERIMENT STATIONS.

A. C. TRUE, Director.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

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[a] Director.
[b] Special agent in charge.
[c] Acting director.

EXPERIMENT STATION WORK.

Edited by W. H. Beal and the Staff of the Experiment Station Record.

Experiment Station Work is a subseries of brief popular bulletins compiled from the published reports of the agricultural experiment stations and kindred institutions in this and other countries. The chief object of these publications is to disseminate throughout the country information regarding experiments at the different experiment stations, and thus to acquaint farmers in a general way with the progress of agricultural investigation on its practical side. The results herein reported should for the most part be regarded as tentative and suggestive rather than conclusive. Further experiments may modify them, and experience alone can show how far they will be useful in actual practice. The work of the stations must not be depended upon to produce "rules for farming." How to apply the results of experiments to his own conditions will ever remain the problem of the individual farmer.—A. C. True, Director, Office of Experiment Stations.

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EXPERIMENT STATION WORK.[a]

WATER REQUIRED FOR CROPS ON RICH AND POOR SOILS.[b]

A fact of immense importance, especially in regions of scanty rainfall, or those subject to severe droughts, has been brought out by investigations reported by J. A. Widtsoe, of the Utah Station, as well as by the work of other investigators. Prof. Widtsoe found "that the amount of water actually required for the production of a pound of dry matter becomes smaller as the available fertility of the soil increases." He states that "this law is not new, but it does not seem to have been applied to the cultural methods in a country where the limiting factor is the water supply."

Prof. Widtsoe found that thorough hoeing or cultivation throughout the season increased materially the yield of dry matter and decreased the amount of water required per pound of dry matter produced, that resting the soil for several years had the same effect, and that on infertile soils the water requirements of crops could be materially lowered by the addition of manure or commercial fertilizers. He believes that in every case the result is to be attributed largely to the plant food set free by the hoeing or fallowing or that added in the fertilizers.

The practical conclusion of all this is simply that, in districts where the rainfall is the chief consideration, it is not sufficient alone to store an abundance of water in the soil, but the soils themselves must be kept in such a condition that plants growing on them can produce dry matter with the smallest possible amount of water. Under a system of dry-farm rotation in which a hoed crop is grown perhaps every other year, in alternation with wheat, a fairly large amount of available plant food will be maintained, but at the same time the amount of stored moisture will be so near the danger limit as to jeopardize seriously the maturing crop. On the other hand, where the soil after being fall plowed and left in the rough throughout the winter is allowed to lie fallow the following summer, a much larger amount of plant food is set free, and at the same time a larger amount of water is stored in the soil. This combination of favorable conditions is much more likely to result in a profitable yield than can any system of culture which tends to weaken one or the other of these vitally important factors. In the Great Basin district, practical experience has demonstrated almost beyond a doubt that summer fallowing is indispensable in successful dry farming. In fact, it has become a doctrine that if land at all adapted to dry farming is summer fallowed every other year a crop failure for want of water is impossible.

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[a] A progress record of experimental inquiries, published without assumption of responsibility by the Department for the correctness of the facts and conclusions reported by the stations.

[b] Compiled from Utah Sta. Bul. 105.

Dry farming lands are fallowed: First, to store in the soil the precipitation of two or more years; and secondly, to set free plant food which will enable the crops to reach maturity with the smallest amount of water. This doctrine explains, undoubtedly, many of the successes and failures on dry farms. Numerous cases are on record where soils under a comparatively abundant rainfall failed to yield well, while other soils under a much smaller rainfall yielded abundantly. There are many soils the available fertility of which is so low that they must be carefully cultivated in order to set free sufficient plant food before successful dry farming can be practiced upon them. This is shown in lands that are allowed to lie fallow for a year after the first plowing before crops are planted. The extraordinary yields sometimes obtained on soils where the rainfall is 12 inches or less may be explained by the naturally large quantity of available plant food found in them.

The understanding of the relationship between soil fertility and transpiration is vital to dry farming, but it is also important to irrigation farming, especially in districts where the water supply is limited. If the irrigation farmer, either by fallowing or by proper manuring, maintains his land in a fertile condition, he will better meet seasons of drought or water shortage than his neighbor whose lands are in an unfertile condition. The principle here discussed must be incorporated into the practice of agriculture in arid regions.

In the Utah experiments it was found that corn required a third less water to mature a pound of dry matter on soil which had been manured or fertilized with nitrate of soda than on the same soil without such treatment.

The important lesson from this work, briefly stated, is that if the farmer wishes to conserve a scanty water supply and use it to the best advantage in the growth of crops he must keep his land rich.

BURNING LIME ON THE FARM.[a]

In a bulletin of the Virginia Experiment Station, dealing very fully with the question of the liming of soils, W. B. Ellett says:

> Many farms are situated long distances from railroads, and the hauling of lime is expensive. Even if the ground limestone is available at prices ranging from $1 to $1.75 [per ton] it would probably be more economical in many cases for farmers to burn their own lime, if good limestone is on or near the farm, thus utilizing their labor to advantage during the winter months. Many farmers in the western section of the State [Virginia] are now burning their own lime, and producing it at a cost of 7 to 9 cents a bushel, instead of 12 cents, the average price of lime from the manufacturer. Cheap coal or wood as well as good limestone are essential to the success of home burning. The rock should "quarry out" easily; that is, it should come out in strata or layers. It should analyze at least 90 per cent of carbonate of lime.

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[a] Compiled from Virginia Sta. Bul. 187.

A suitable location near the quarry is chosen, preferably the side of a hill. An excavation is made 10 feet into the hill, and to a depth of 7 feet. [Fig. 1.] The width of the kiln is 8 feet at its greatest breadth, sloping gently at the bottom. A trench 18 inches wide and 1 foot deep is dug through the center, at the base of the kiln. Across the trench are placed pieces of old castings, which serve the purpose of a grate. The front and side walls of the kiln are built like a retaining wall. The rear walls are sometimes built of rock, but usually no wall is built, as the sides of the hill answer this purpose. The general plan of the kiln is oval, both at the base and top.

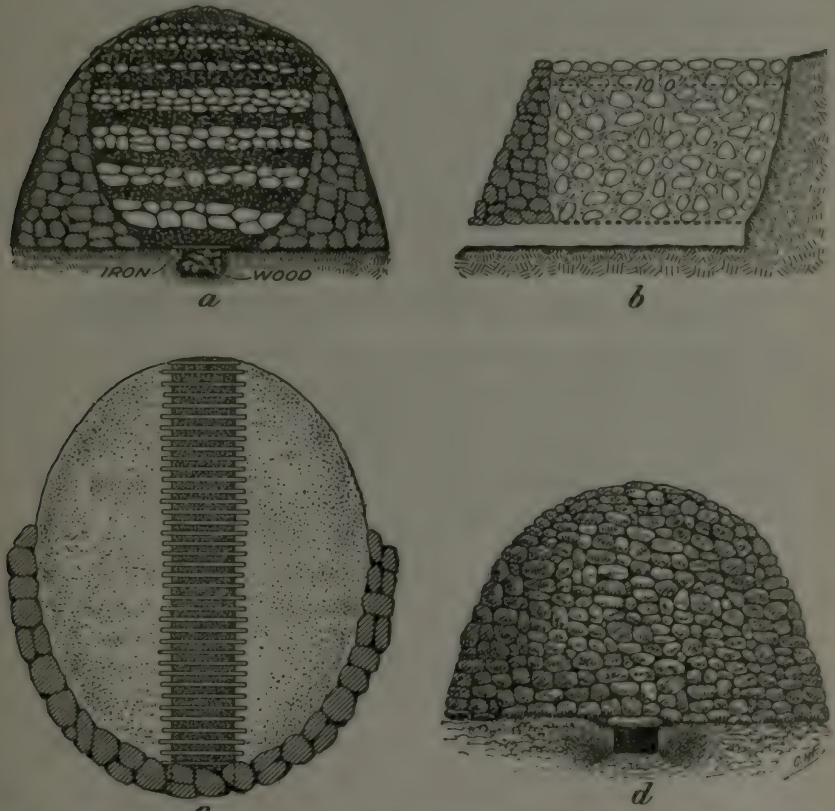

FIG. 1.—Details of construction of a farm limekiln: *a*, Cross section, showing layers of rock and coal; *b*, longitudinal section, showing side hill used as back wall; *c*, ground plan, showing trench and grate; *d*, completed kiln, walled in and plastered with mud.

Over the grate in the center of the kiln, at the bottom, is placed a layer of coal of sufficient size not to pass through the openings. On top of this layer of coal is placed the limestone rock, which may vary in size from 6 to 12 inches in diameter. Alternate layers of fine coal and rock are now introduced, and this is continued until the kiln is filled, leaving an opening in the rear, at the top, large enough to serve the purpose of a flue. When the kiln has been filled, it is covered with a layer of flat rocks and the front is then inclosed with rock and sealed with mud. In the trench at the bottom of the kiln enough wood is introduced to set fire to the coal. The burning is continued for from 2 to 3 days, with 3 to 5 days for cooling.

A kiln of these dimensions will furnish from 250 to 300 bushels of stone lime at each charge. The amount of coal used to a charge is 100 bushels to 300 bushels of rock. If much magnesia, silica, and alumina are present in the limestone, it fuses readily, and in such cases care must be taken to keep the temperature below the melting point, so as to prevent the formation of slag, and the making of "dead-burnt" or "overburnt" lime.

To build and operate the kiln requires the services of one man from 8 to 10 days, at a cost of about $1.50 per day. The coal used varies in amount with the rock, but usually 1 bushel of coal is used to 3 of limestone; and in a kiln of this size 100 bushels of coal is used with 300 bushels of limestone rock.

An average charge against the kiln would be:

1 man for 10 days, at $1.50	$15.00
100 bushels coal, at 7½ cents	7.50
Wood for igniting the charge	.50
Total	23.00

The yield of good stone lime should be 250 bushels. This would make a ton of lime cost the farmer $2.25, or a fraction above 9 cents for a bushel. This price would be considerably less than the farmer would have to pay for lime from a dealer.

GROWING TOMATOES FOR THE CANNING FACTORY.[a]

The annual pack of tomatoes in the United States is probably not less than 10,000,000 cases. The growing of tomatoes for canning is therefore an important agricultural industry. A large part of the crop for this purpose is grown by the general farmer rather than by a specialist, and as a rule not as much care is taken with it as is necessary to yield the greatest profit.

A bulletin of the Indiana Experiment Station, by J. Troop, C. G. Woodbury, and J. G. Boyle, summarizes the results of a study of tomato growing for canning in Indiana, and on the basis of the observations so made calls attention to some of the weak points in present methods of producing canning tomatoes, particularly as applied to practice in Indiana, but also applicable in large measure to other parts of the country. It is pointed out that it is especially necessary that greater care should be exercised in growing the young plants, and that millions of inferior plants are now set, either as the result of poor seed or unskillful growing, reducing greatly the yield and profit from the crop. It was also found that as a rule the soil was not prepared as thoroughly as it should be, and that more time, labor, and money might profitably be given to drainage and fertilizing. "Thousands of farmers are failing in growing tomatoes because they do not realize the soil and cultural requirements of the plant." The necessity for constant and thorough cultivation is not fully recognized. "It is probable that neglect of cultivation is responsible for a greater proportion of unprofitable tomato yields than any other single factor entering into the production of the crop."

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[a] Compiled from Indiana Sta. Bul. 144.

More careful handling of the vines during the picking season is urged, for it was observed that in many tomato fields "careless picking and rough treatment of the plants so cut down the total salable product that the cash returns barely paid for the expense of growing and marketing." Finally, the opinion is expressed that it would be more profitable to plant smaller areas and to practice more intensive methods of culture than is the case at present.

From the more detailed description of methods of culture given in the bulletin the following brief statement of some of the more important points has been compiled: It is stated that the highest yields are being secured in Indiana on sandy loam soils which are well drained and comparatively rich in plant food. If the soil is in sod or contains considerable clay, it is usually best to plow rather deep in the late fall and disk every two weeks in the spring until the young plants are ready to be set out.

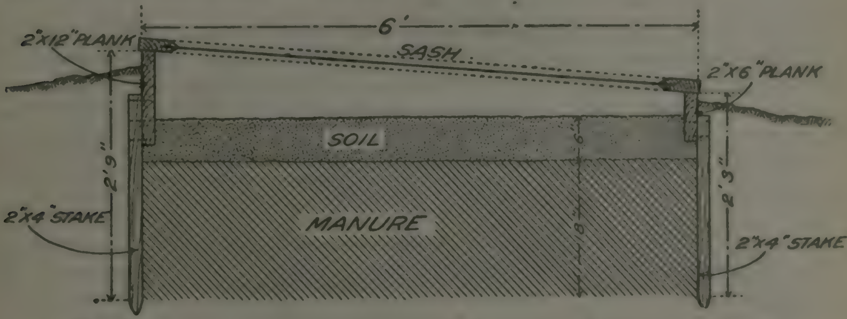

FIG. 2.—Section showing the construction of a hotbed for tomato plants.

> Just before transplanting, the soil should be put into as fine tilth as possible. This can be done with from two to four thorough harrowings, the last one coming immediately before the plants are set in the field * * *. The depth of plowing should be 8 inches or even more if the subsoil is not too near the surface.

After the soil has been put in the best possible state of tilth, if it is deficient in plant food, it should be liberally fertilized with well-rotted barnyard manure, which may be supplemented with commercial fertilizers if the soil is not rich enough to give the plants a good start when set in the field.

One of the first considerations in producing strong, healthy plants is the securing of good seed. Such seed are usually furnished by the canning companies, but it is advisable to make germination tests of the seed before planting. Plants are grown in hotbeds, cold frames, or in seedbeds in the open ground.

> The safest and surest way of growing tomato plants is by the use of hotbeds. These can be constructed of 2-inch planks nailed or bolted together in the form of a rectangular box, generally 6 feet wide and as long as desired. [Fig. 2.] The box should be so made that when the bottom is level, the sash will slope 1

inch to the foot, which will make it 6 inches higher on one side than on the other. This slope permits the sun's rays to enter more freely and allows water to run off quickly. The bed should be located on a southern slope if possible and run east and west, with the lower side of the frame toward the south. If a southern exposure can not be secured, a windbreak may be constructed on the north side and the ends to shut off the cold winds from these directions. The beds should also be near the house and near a plentiful supply of water in order that the plants may be carefully and easily cared for.

Common stable horse manure containing no litter, mixed with from one-third to one-half its amount of straw or leaves, is used for providing the artificial heat. Straw or leaves should be added to prolong the heating period of the manure and to keep it from heating too violently. The manure is gathered fresh from the stable, piled up, and allowed to heat. When heated through it is forked over and allowed to heat again. During the heating it should be kept under shelter, as heavy drenchings make it almost worthless. After it is well heated through the second time, it is put in the hotbed excavation almost to the sash level, care being taken to spread it evenly and to have the corners well filled. After the manure has again warmed up it should be firmed by tramping. The bed is now ready for the soil.

Five or six inches of rich soil containing much humus and sand are then placed upon the manure, and after the temperature of the soil has dropped to 90° F. the seed may be sown. A good soil for this purpose can be prepared by making a compost heap consisting of alternate layers of June grass sod and barnyard manure eight or ten months before it is to be used. This will give a loose, rich soil very well adapted to hotbed work.

The bed should be prepared early in the spring, so that the seed may be sown from the first to the middle of March, which will give plenty of time for the developing of good-sized plants. The seed should be sown thinly from one-fourth to one-half inch deep, and preferably in rows 4 to 6 inches apart, thus giving an opportunity for thinning and stirring the soil. Broadcast sowing, although not uncommon, is not to be recommended.

On warm days the bed should be ventilated to make the plants grow stocky and prevent them from wilting. Tomatoes thrive best at a temperature of from 75° to 85° during the day and about 60° at night. In watering the aim should be to water thoroughly, but not often. The practice of adding a small amount of water each day should never be followed, as it encourages the growth of insects and diseases, and benefits the plant but little, since the moisture does not reach the roots.

A week or ten days before the time to transplant into the field, or earlier, if the weather permits, the sash should be removed during the day to harden off the plants. It is also a good plan to stop watering at this time, and then wet down thoroughly just before taking to the field.

Different materials are used for covering hotbeds. A cheap and quite common one is light canvas or heavy sheeting which has been oiled. A more substantial covering is the hotbed sash, which is coming into use more and more, as it is more reliable than the cloth, and makes it possible to control the temperature with more certainty.

A cold frame differs from a hotbed in that no artificial heat is used. They are usually started and the seed sown the last of March or first of April. Otherwise their construction and care is the same as that given above for hotbeds.

The growth of plants in seedbeds in the open ground is not considered satisfactory in the latitude of Indiana.

The young plants are set in the field as soon as possible after danger of frost is past, usually from May 15 to June 10, in Indiana. The best time for transplanting is on cloudy days, when the soil is moist, or in the mornings and evenings if the days are warm and sunshiny. The depth of setting varies with the size of the plants. If they are short and stocky 4 to 6 inches is sufficient, but if the stems are long they may be set even a foot deep without injury, if the subsoil permits. The plants should be set at distances of from 4 by 5 to 5 by 5 feet with the varieties that are now being grown for canning purposes. As soon as possible after the plants have been set in the field they should be cultivated, and the first cultivation may be rather deep and close to the plants, the shovels of the cultivator being set to throw the dirt slightly toward them. Shallow cultivation farther away from the plants should follow at intervals of from 7 to 10 days. Cultivation should cease, as a rule, when the first fruits are beginning to set on the vines.

If the plants are still small they may be cultivated once between each row, care being taken not to shake the vines, which causes the small fruit to drop. Plants properly cared for will usually cover a considerable portion of the ground when the fruits begin to form, thus preventing evaporation to a great extent. Throughout the remainder of the season, two or three thorough hoeings will generally be sufficient to keep the weeds under control.

The tool commonly used in caring for the crop is the two-horse corn cultivator. One of these should be selected with several small teeth to break the soil in preference to those having two large shovels, which leave the soil in ridges. Level and shallow cultivation is preferable to hilling or ridging.

The time of harvesting depends to a large extent on the time of transplanting and the weather conditions when the first fruits are setting. Under favorable conditions the first picking occurs about 80 days after the plants are set in the field. As already indicated, care should be taken in removing the fruits not to move the vines more than is absolutely necessary.

The favorite variety throughout the tomato-growing section of Indiana is the Stone, although this variety is not considered ideal for the purpose. A good type of tomato for canning purposes should possess the following characteristics:

(1) Fruit smooth, without ridges and without a depression at the stem end; (2) interior firm and well formed; (3) vine an upright grower, with strong stems; (4) plant producing a large weight of fruit throughout the season; (5) uniform red color, which remains bright during preserving processes.

The tomato is subject to attacks of various insect pests and diseases, among which are the tomato worm, which can be controlled by the use of sprays of Paris green and arsenate of lead or by hand picking; cutworms, which may be controlled to some extent by plowing the soil two weeks before transplanting and by the use of poisoned baits; the stalk borer, which may be controlled to some extent by the preventive measures of keeping the field free from weeds and foreign plants and practicing a rotation of crops; point rot, for which there is at present no effective means of control; ripe rot or anthracnose, the injury from which may be reduced by destroying diseased fruits and planting far enough apart to admit light and air into the plants; and leaf-spot diseases, the standard remedy for which is spraying with Bordeaux mixture.

It is stated that with proper care and a good season without exceptional losses from insects and diseases yields may be expected to run from 6 to 12 tons per acre in Indiana. The opinion is expressed that the yield could easily be raised to 12 or 15 tons per acre by following the improved methods suggested. Roughly speaking, it requires a yield of at least 5 tons per acre to pay expenses at the usual contract prices. The cost of growing depends largely upon the methods followed. Estimates of reliable growers place it at from $25 to $50 per acre. Probably $35 may be considered a fair estimate. The price received for the crop varies from $7 to $8.50 per ton. It thus appears that under the best conditions a profit of from $50 to $75 per acre may be realized. If, however, "the crop does not receive the care and attention that it should, the profits are often very small, and in some cases the grower does not get any more out of his crop than the cost of producing it."

The whole subject of tomato culture, including growing for canneries, is treated by L. C. Corbett in a Farmers' Bulletin of this Department,[a] the purpose of this article being to call particular attention to certain points which have been found to be neglected in practice.

LIME SULPHUR AS A FUNGICIDE.[b]

The use of some form of lime sulphur as a substitute for Bordeaux mixture in combating fungus diseases of the orchard is at the present time of great interest to fruit growers, as is evidenced by the constant demand for definite and reliable data on the fungicidal value of the various lime-sulphur mixtures.

Some form of powdered sulphur has been used for years by the French vineyardists in combating the grape oïdium, a fungus disease which often causes serious losses to European vine growers. On the

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[a] U. S. Dept. Agr., Farmers' Bul. 220.

[b] Compiled from Delaware Sta. Bul. 85; Maryland Sta. Bul. 143; Michigan Sta. Bul. 49; New York Cornell Sta. Bul. 276; New York State Sta. Bul. 320; Oregon Sta. Bul. 106; Pennsylvania Sta. Bul. 92; Tennessee Sta. Bul. 88; Virginia Sta. Bul. 188; U. S. Dept. Agr., Bur. Plant Indus. Buls. 155, 174; Circs. 27, 54, 58; The summer use of concentrated lime sulphur, by H. H. Whetzel: Reprint from Proc. N. Y. State Fruit Growers' Assoc., 9 (1910), pp. 31–44; Rev. Vit., 33 (1910), No. 862, pp. 691, 692; Jour. Bd. Agr. [London], 17 (1910), No. 3, pp. 184–189; Fruit-Grower, 20 (1909), No. 1, pp. 6, 7.

Pacific slope home-boiled lime-sulphur preparations have been used for a number of years in fighting the San José scale, but only in recent years has the use of lime sulphur as a general fungicide been considered and experiments carried out on a large scale to determine the efficiency of the various lime-sulphur mixtures in controlling fungus diseases, especially of the orchard.

The standard fungicide is Bordeaux mixture, but this spray on certain varieties of trees and under certain weather conditions often russets the fruit or causes serious damage to the foliage, especially when used during the summer. This is the case with many varieties of stone fruits, notably the peach. For this reason there is a demand for a spray that can be used on the foliage of these more sensitive trees without injury, and yet control the prevalent and injurious fungus diseases to which they are subject.

There are three types of lime-sulphur sprays, as follows: Self-boiled lime-sulphur mixture, home-boiled lime-sulphur wash, and factory-boiled lime-sulphur solution, or concentrated lime sulphur, as it is usually known.

The self-boiled lime-sulphur mixture of Scott, which was developed primarily for spraying peach trees, is the spray commonly meant when speaking of the self-boiled lime-sulphur preparations. It is made by using 8 pounds of fresh stone lime and 8 pounds of sulphur—either flowers or flour of sulphur—to 50 gallons of water, commonly designated as an 8:8:50 mixture, or the strength may vary from 6:6:50 to 10:10:50, governed by the time of year it is to be applied, the kind of fruit trees to be sprayed, and the fungus to be controlled. The mixture can best be prepared in rather large quantities, say, enough for 200 gallons at a time, making the formula 32 pounds of lime and 32 pounds of sulphur to be cooked with a small quantity of water—8 or 10 gallons—and then diluted to 200 gallons. The lime should be placed in a barrel and enough water poured on to almost cover it. As soon as the lime begins to slake the sulphur should be added, after first running it through a sieve to take out the lumps. The mixture should be constantly stirred and more water added as needed to form a thick paste at first, and then gradually a thin paste. The lime will supply enough heat to boil the mixture several minutes. When well slaked, water should be added to cool the mixture and prevent further cooking. It is then ready to be strained into the spray tank, diluted, and applied. Care must be taken not to allow the boiling to proceed too far, as some of the sulphur will then go into solution, forming sulphids, which are injurious to the foliage. The intense heat, violent boiling, and constant stirring results in a uniform mixture of finely-divided sulphur and lime, with only a very small percentage of the sulphur in solution. This mixture should be applied immediately after it is made with a good spraying outfit equipped with an agitator, Vermorel nozzles, etc.

The home-boiled concentrated lime-sulphur solution—Cordley's—is prepared as follows: Sulphur, 110 pounds; good stone lime, 25 pounds. Slake the lime in a kettle, making a paste of the sulphur with a little water, add the sulphur paste to the slaked lime, and add water to make 60 gallons. Boil 30 to 40 minutes. Allow to settle, and then pour off the clear, amber liquid, of which there should be approximately 45 gallons, testing 30° by the Baumé hydrometer. This concentrated stock solution is then diluted to 1:12, 1:30, etc., according to the season of the year and the trees to be sprayed.

The commercial lime-sulphur concentrated solutions were first devised as a substitute for the ordinary home-boiled lime-sulphur preparations used for San José scale. Several of these brands on the market have been tested by reliable experimenters in the United States for the control of certain orchard diseases. These concentrated lime-sulphur mixtures must be diluted before using as fungicides.

Of the three types of lime-sulphur preparations, the so-called self-boiled lime-sulphur spray of Scott has probably been the most widely and thoroughly tested by reliable investigators and orchardists as to its fungicidal value in combating the various orchard diseases. W. M. Scott, of the Bureau of Plant Industry, has been especially active in the past three years in testing its efficacy as a substitute for Bordeaux mixture on fruit trees where the Bordeaux spray would injure the fruit or the foliage. These experiments have included tests on peach brown rot, peach scab, cherry leaf spot, apple scab, apple leaf spot, sooty mold, bitter rot, and apple blotch, in many States, and with various varieties of peaches and apples. The efficiency of the self-boiled mixture in controlling the peach brown rot and peach scab has been tested in Georgia, Arkansas, West Virginia, Delaware, Maryland, Tennessee, and Illinois, and in the majority of cases has proved very successful, especially in Georgia, Arkansas, West Virginia, and Illinois, where the peach trees were sprayed three to four times with an 8:8:50 solution, to which 2 pounds of arsenate of lead was added when the curculio was bad.

In addition to controlling the brown rot and the scab without injury to the foliage, the fruit sprayed with the self-boiled lime-sulphur was larger, more highly colored, presented a much better appearance in the package, carried to market better, and commanded a higher price than the unsprayed fruit. However, there is some danger of staining the fruit if the mixture is applied within two or three weeks of the ripening period.

Very satisfactory results were obtained with this mixture in controlling the cherry leaf spot and leaf diseases in general of the peach and cherry. On varieties of apples subject to russeting and foliage injury from Bordeaux mixture, the self-boiled lime-sulphur preparation has proved a good substitute for controlling leaf spot, fruit spot, sooty fungus, and for mild cases of scab infection, without injury to the fruit or foliage, but is of doubtful value in controlling apple blotch and bitter rot. Two pounds of arsenate of lead added to every 50 gallons of the self-boiled mixture proved of value in controlling the codling moth and was entirely harmless to the apple foliage.

The self-boiled lime-sulphur mixture seems, therefore, to be of value, especially as a summer spray for the fungus diseases of the peach and cherry and for several diseases of the apple, and does not injure the foliage nor fruit when properly prepared and applied. It has not proved efficient in this country against black rot of the grape, although a modified self-boiled lime-sulphur mixture consisting of 2 pounds of sulphur, 1 pound of lime, and 2 pounds of copper sulphate, diluted to 1 and 1½ per cent solutions, is reported by a French vineyardist as having given complete protection to his vineyard of 30,000 plants against the grape oïdium for the past 10 years. A somewhat similar spray has recently been tested by M. B. Waite, of the Bureau of Plant Industry, on the apple with success against fungus diseases, but with some russeting and foliage injury to certain varieties.

The self-boiled lime-sulphur mixture has also been tested on tomatoes, cabbages, onions, strawberries, peas, celery, sweet potatoes, asparagus, and cantaloups, chiefly to ascertain whether injurious effects would ensue. With the exception of the cantaloups, no damage was noted on the plants sprayed, and slight if any benefit was derived in the prevention or control of diseases.

The home-boiled and commercial lime-sulphur sprays are preparations in which much of the sulphur has chemically combined with the lime, forming various sulphids, some of which are very injurious to the foliage of grapes, peaches, and apples, but with the proper dilution both have proved valuable fungicides in controlling certain diseases. The commercial lime-sulphur spray has proved very effective against peach leaf curl and apple scab, but fruit subject to bitter rot must be treated with a stronger fungicide. The dilution of the self-boiled and commercial mixtures varies with the time of application, variety of tree, and the disease. In some instances serious injury to foliage has followed the application of too concentrated solutions, especially of the commercial preparations. Arsenate of lead may be used with either preparation without any additional risk of foliage injury.

In general, then, it would seem that the self-boiled lime-sulphur mixture is the best for the peach, and either the commercial or the home-boiled solution for the apple. The home-boiled mixture has also been tested in England on the hop mildew, gooseberry mildew, and apple scab, where it was very efficacious in combating the hop mildew, and is recommended for trial against powdery mildews and apple scab.

For details as to number of applications, dilutions to be used, methods of preparation, etc., see list of bulletins from which this compilation was made on page 12, especially Bureau of Plant Industry Bulletin 174 and Circulars 27 and 54.

MARKET CLASSES AND GRADES OF MEAT.[a]

The importance of a knowledge of the standard requirements of the meat market on the part of the producer is pointed out by L. D. Hall in a bulletin of the Illinois Station dealing in a very comprehensive way with the market classes and grades of meat.

> Breeders, feeders, or investigators who consider only the cost of production and the market value of the live animal, ignoring the demands of the meat trade, overlook one of the most important factors that affect the live-stock market and may thus fail to follow the most rational lines of improvement in breeding and feeding. * * * With an understanding of meat-trade requirements it is possible for a stockman to judge the carcass yield and quality of his animals as intelligently as buyers at the stockyards; because his knowledge of the feeds used, length of feeding period, and gains made are as essential in making such estimates as the apparent form, condition, and quality of the fat animal, upon which points the buyer must chiefly rely.

The descriptions presented below are based on data secured in an investigation at wholesale meat markets at the Union Stock Yards, Chicago, and also at prominent wholesale and retail markets in Chicago and other cities which are supplied from the large houses at the Union Stock Yards, and may be considered standard for all the great packing centers of this country; and since most American wholesale markets are supplied from these centers, the classification may be regarded as standard for the country. It should be borne in mind that the classifications are those of the wholesale meat trade and not of the live-stock market, and that the weights given refer to dressed carcasses and cuts, and in no case to live animals.

BEEF.

1. **Carcass beef.**—This includes both full sides and quarters (fig. 3). The classes are steers, heifers, cows, and bulls and stags. The classes differ not only in sex, but also in the uses to which they are adapted.

The grades within the classes are prime, choice, good, medium, common, and canners. The grades are based on differences in form, thickness, finish, quality, soundness, and weight.

"Native" carcass beef has sufficient finish to indicate grain feeding, is comparatively compact in form, thickly fleshed, mature in proportion to age, and consists chiefly of medium to prime steers, heifers, and cows of the heavier weights. "Westerns" are relatively "rangy" in form, "grassy" in color and general appearance, coarser in quality and inferior to "natives" in finish, consisting largely of common to good cows and steers. "Texas" beeves are light-weight carcasses, inferior to "Westerns" in form, finish, and quality, usually bruised and showing considerable age, consisting chiefly of medium, common, and canner cows and steers. These terms have much less geographical significance than formerly.

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[a] Compiled from Illinois Sta. Bul. 147, Abstract.

"Yearlings" are carcasses of young steers and heifers of 400 to 700 pounds dressed weight, with sufficient quality and finish to be sold at retail on the butcher's block. "Butcher cattle" are those especially adapted to "butcher-shop" trade and consist principally of medium to choice heifers, steers, and cows. "Kosher" cattle are beeves that have been slaughtered, inspected, cleansed, and labeled in accordance with Jewish rites, and include medium to choice steers, cows, and heifers. "Distillers" are steers, bulls, and stags that have soft, "washy" flesh and "high color," characteristic of cattle fattened on distillery slops. They are principally of medium and good grades.

"Shipping beef" refers to that sent to Eastern cities and consists chiefly of steers, heifers and cows of medium to prime grades. "Export beef" is made up mainly of medium to choice steers, and includes good and choice heifers, heavy cows, bulls, and stags.

2. Beef cuts.—The "straight cuts" are loins, ribs, rounds, chucks, plates, flanks, and shanks (fig. 3).

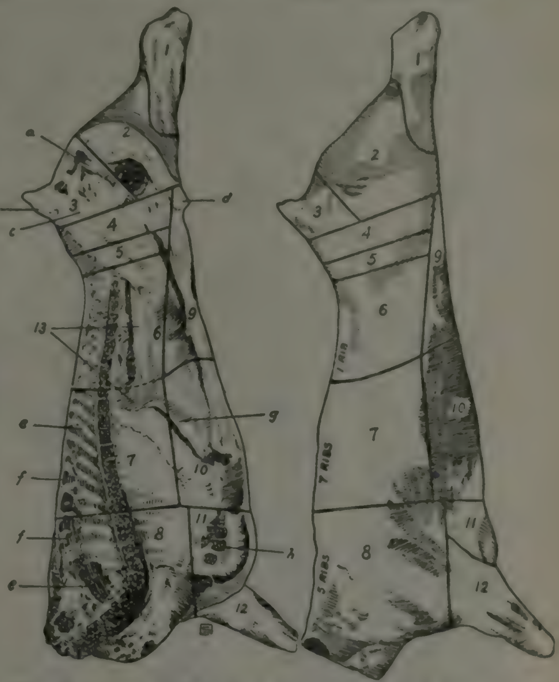

FIG. 3.—Cuts of beef: 1, 2, 3, round; 4, 5, 6, loin; 7, rib; 8, chuck; 9, flank; 10, 11, plate; 12, shank; 13, suet; 1, hind shank; 2, round (rump and hind shank off); 3, rump; 4, 5, loin end; 6, pinbone loin; 5, 6, flatbone loin; 10, navel; 11, brisket; 1, 2, 3, 4, 5, 6, 9, hind quarter; 7, 8, 10, 11, 12, fore quarter; 7, 8, back; 7, 10, piece; 8, 11, 12, Kosher chuck; 8, 10, 11, 12, triangle; *a*, aitch-bone; *b*, rump-bone; *c*, crotch; *d*, cod; *e*, chine-bones; *f*, "buttons;" *g*, skirt; *h*, breast-bone.

The grades of beef cuts are No. 1, No. 2, No. 3, and strippers. The grade of a cut depends upon its thickness, covering, quality, and weight.

Percentage of "straight" beef cuts to carcass weight.

Cuts.	Loins.	Ribs.	Round.	Chucks.	Plates.	Flanks.	Shanks.	Suet.
Extreme	15-19	8-11	20-26	21-27	12-16	2-5	3-7	2-7
Conventional	17	9	23	26	13	4	4	4

Various other wholesale cuts are made from the "straight" cuts, and in general are graded in a similar manner (fig. 3).

3. Cured beef products.—These are (1) barreled, (2) smoked, and (3) canned beef.

Barreled beef is packed in brine. The standard grades are extra India mess, extra plate, regular plate, packet, common plate, rolled boneless, prime mess, extra mess, rump butt and mess chuck beef, beef hams, and Scotch buttocks.

Smoked beef is cured in sweet pickle, dried, and smoked. It consists of dried beef hams, dried beef clods, and smoked brisket beef.

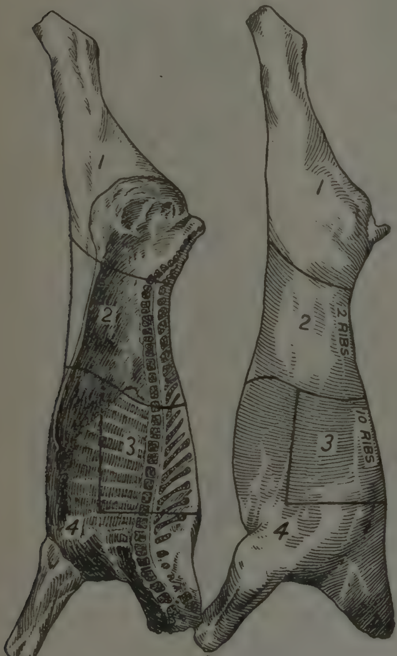

FIG. 4.—Cuts of veal: 1, 2, saddle (or 2 hind quarters); 3, 4, rack (or 2 fore quarters); 1, leg; 2, loin; 3, ribs; 4, stew.

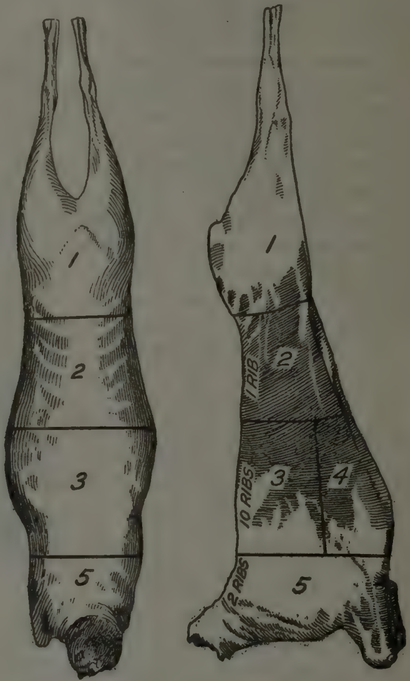

FIG. 5.—Cuts of mutton and lamb: 1, 2, saddle; 3, 4, 5, rack; 1, 2, 3, long saddle; 2, 3, 4, 5, body; 1, leg; 2, loin; 3, short rack; 2, 3, back; 4, breast; 5, chuck; 4, 5, stew.

Canned beef is sealed in tins or glass jars, usually after partial curing and cooking. It consists principally of chipped beef, beef loaf, corned beef, and roast beef.

VEAL.

1. Carcass veal.—This consists of whole carcasses, which are usually sold with the skin on.

The grades are choice, good, medium, light, and heavy. The grade of a carcass is determined by its form, quality, finish, and weight.

"Native" calves have white, fine-grained flesh and long, soft hair. "Westerns" have comparatively coarse, dark-colored flesh, "rangy" form, and short, straight hair.

2. Veal cuts.—The regular cuts are saddles and racks. Each is about one-half, by weight, of the skinned carcass (fig. 4). They are graded as choice, good, medium, and common, according to the same factors as carcass veal.

Subdivisions of the regular cuts are made in some markets, and similarly graded (fig. 4). Veal legs and stews each contain about one-third the carcass weight; ribs and loins about one-sixth each.

MUTTON AND LAMB.

1. Carcass mutton and lamb.—The classes are wethers, ewes, bucks, yearlings, and lambs. The classification is based on differences in sex and degree of maturity.

The grades within the classes are choice, good, medium, common, and culls. The grade of a carcass is determined by its form, quality, covering, and weight.

The shipping trade goes principally to cities in the eastern seaboard States and consists largely of medium to choice lambs.

2. Mutton and lamb cuts.—Saddles and racks are the cuts most commonly made; but legs, loins, short racks, stews, and backs are also quite extensively sold (fig. 5). These cuts are graded as choice, good, medium, and common, according to their shape, quality, covering, and weight. In relative weights, the various cuts are similar to the corresponding cuts of veal.

PORK.

1. Dressed hogs.—The classes are smooth heavy, butcher, packing, and bacon hogs, shippers, and pigs. The classification is based on the uses to which the hogs are adapted.

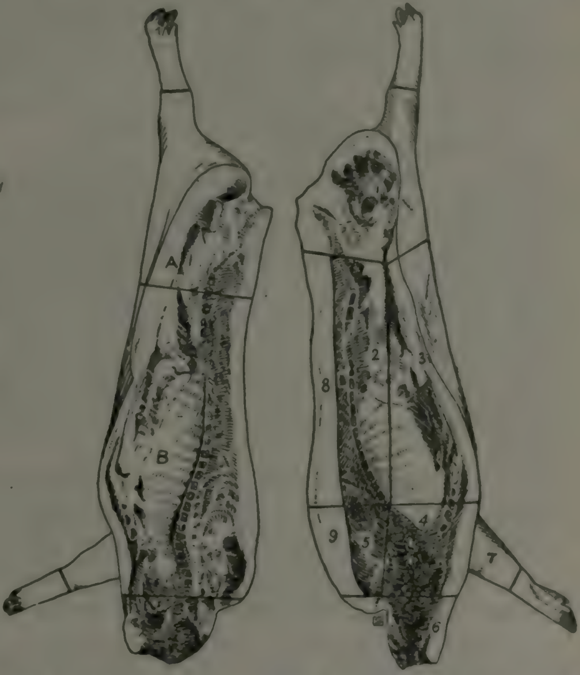

FIG. 6.—Cuts of pork: English cuts—A, long-cut ham; B, long side or middle. Domestic cuts—1, short-cut ham; 2, loin; 3, belly; 4, picnic butt; 5, Boston butt; 6, jowl; 7, hock; 8, fat back; 9, clear plate; 2, 8, back; 2, 3, 8, side; 4, 7, picnic shoulder; 5, 9, shoulder butt; 8, 9, long fat back; 4, 5, 7, 9, rough shoulder.

Distinct grades are recognized only in the packing and bacon classes, the former being based on weight and the latter chiefly on quality and finish.

2. Pork cuts.—The classes are hams, sides, bellies, backs, loins, shoulders, butts and plates, and miscellaneous, these being determined by the parts of the carcass from which they are made (fig. 6).

The grades and methods of grading vary widely in the different classes of cuts, and involve not only their quality, shape, finish, and weight, but also the styles of cutting and methods of packing used.

Pork cuts are quoted as fresh pork, dry-salt, and bacon meats, barreled or plain-pickled pork, sweet-pickled meats, smoked meats, "English" meats, and boiled meats, respectively.

3. **Lard.**—The grades are kettle-rendered leaf, kettle-rendered, neutral, prime steam, refined, and compound lard. The grading is based on the kinds of fats included, method of rendering, color, flavor, and grain.

KEEPING POULTRY FREE FROM LICE.[a]

As pointed out in a bulletin of the Maine Experiment Station by Raymond Pearl and Frank M. Surface, "one of the most difficult and trying problems which the poultry keeper has to meet is that of keeping his poultry houses and stock reasonably free from lice, mites, and other external parasites."

After testing various proprietary preparations and finding most of them very expensive in proportion to their efficiency the station adopted the use of preparations based upon formulas proposed by R. C. Lawry, of the New York Cornell Experiment Station, with very satisfactory results.

For the birds themselves experience has shown that the best way to get rid of the lice is by the use of a dusting powder to be worked into the feathers. In using any kind of lice powder on poultry * * * it should always be remembered that a single application of powder is not sufficient. When there are lice present on a bird, there are always unhatched eggs of lice ("nits") present, too. The proper procedure is to follow up a first application of powder with a second at an interval of four days to a week. If the birds are badly infested at the beginning, it may be necessary to make still a third application. To clean the cracks and crevices of the woodwork of houses and nests of lice and vermin, a liquid spray or paint is probably the most desirable form of application.

The lice powder used is prepared by mixing three parts of gasoline with one part of crude carbolic acid, 90–95 per cent strength, or, if the latter can not be obtained, with one part of cresol, and adding gradually, with stirring, enough plaster of Paris to make when the liquid is uniformly distributed through the mass of plaster a dry, pinkish-brown powder having a fairly strong carbolic odor and a rather less pronounced gasoline odor. As a general rule, it will take about 4 quarts of plaster of Paris to 1 quart of the liquid.

This powder is to be worked into the feathers of the birds affected with vermin. The bulk of the application should be in the fluff around the vent and on the ventral side of the body and in the fluff under the wings. * * *

For a spray or paint to be applied to roosting boards, nest boxes, or walls and floor of the hen houses the following preparation is used: Three parts of kerosene and 1 part crude carbolic acid, 90–95 per cent strength. This is stirred up when used and may be applied with any of the hand spray pumps or with a brush. If 90–95 per cent crude carbolic acid can not be obtained, cresol may be substituted for it in this paint.

The routine methods used by the station are as follows:

All hatching and rearing of chickens is done in incubators and brooders. The growing chickens are never allowed to come into any contact whatever with old hens. Therefore, when the pullets are ready to go into the laying houses in the fall they are free from lice. Sometime in the late summer, usually in August or early in September, the laying houses are given a thorough cleaning. They are first scraped, scoured, and washed out with water thrown on the walls and floor with as much pressure as possible from a hose. They are then given two thorough sprayings, with an interval of several days intervening, with a solution of cresol[a] * * *. Then the roosting boards, nests, floors, and walls to a height of about 5 feet are thoroughly sprayed with the lice paint (kerosene oil and crude carbolic acid described above). Finally, any yearlings, or older birds, whether male or female, which are to be kept over for the next year's work are given two or three successive dustings, at intervals of several days to a week between each application, with the lice powder described above before they are put into the clean houses.

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[a] Compiled from Maine Sta. Bul. 179, p. 78.

As a result of these methods, the station's poultry plant is at all times of the year practically free of lice.

NEUFCHATEL CHEESE.[b]

The soft-curd rennet cheese known as Neufchatel, made extensively in the Department of Seine-Inférieure, France, from cow's milk, either whole or skimmed, has become very popular in the United States, but in this country the process of manufacture has been considerably changed, so that as now made it represents a different type and is ready for use as soon as made, whereas the French variety is allowed to ripen for several weeks. A recent Cornell bulletin describes the process of manufacture as now practiced in both countries.

Foreign method of manufacture.—Fresh milk is set at 85° F., with sufficient rennet to cause a thorough coagulation in twenty-four to thirty-six hours. The curd is then placed in cheesecloth bags and allowed to drain for some twelve to twenty-four hours. The draining is assisted by the application of light pressure. When the curd is dry enough it is pressed into cylindrical shapes 1¾ by 3 inches, and salted from the outside. It is then allowed to drain for several hours and is placed in a ripening room, where in a few weeks it becomes covered with white and blue mold. The cheese is then placed in a cellar for further ripening, and when red spots appear on the outside it is wrapped in paper and tinfoil and marketed.

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[a] This cresol solution is prepared as follows: Measure out 3⅓ quarts of raw linseed oil in a 4 or 5 gallon stone crock; then weigh out in a dish 1 pound 6 ounces of commercial lye or "Babbit's potash." Dissolve this lye in as little water as will completely dissolve it. Start with one-half pint of water, and if this will not dissolve all the lye add more water slowly. Let this stand for at least three hours until the lye is completely dissolved and the solution is cold; then add the cold lye solution very slowly to the linseed oil, stirring constantly. Not less than five minutes should be taken for the adding of this solution of lye to the oil. After the lye is added continue the stirring until the mixture is in the condition and has the texture of a smooth, homogeneous liquid soap. This ought not to take more than a half hour. Then while the soap is in this liquid state and before it has a chance to harden add, with constant stirring, 8½ quarts of commercial cresol. The cresol will blend perfectly with the soap solution and make a clear, dark-brown fluid. The resulting solution of cresol soap is then ready to use. This cresol soap will mix in any proportion with water and yield a clear solution.

[b] Compiled from New York Cornell Sta. Bul. 270; North Carolina Sta. Bul. 210.

American method of manufacture.—Fresh sweet milk is heated to 165° F. for ten minutes and then cooled immediately to 72° F. Until very recently, the milk used was not pasteurized, but the great difficulty in securing reliable milk, together with the advantages of pasteurization and the use of a commercial starter, have made the heating method very popular.

In large factories the cheese is made in large vats, but on the farm it can be made in smaller quantities in shotgun cans holding about 30 pounds of milk. After the milk is cooled to 72° F., a small amount of commercial starter is added and enough rennet to insure a thorough coagulation in eighteen hours. Usually about 1 cubic centimeter of commercial starter and ½ cubic centimeter of rennet extract is sufficient to 30 pounds of milk if the temperature is maintained at 72° F. As soon as the milk is firmly coagulated it is placed on a cotton-covered strainer rack or in cotton bags to drain. The acidity of the exuding whey at this time should be not over 0.3 per cent or the flavor of the cheese will be too acid. The draining process requires several hours and should be kept up until all free whey has escaped. Light pressure, such as can be obtained in a small cheese press, aids materially in expelling the whey. During the draining process the curd on the outer surface of the strainer should be stirred occasionally to insure even drying. As soon as the curd is sufficiently dry, salt is added at the rate of 2¼ ounces to 10 pounds of curd. At this time the acidity of the whey should be not over 0.5 per cent. The cheese should then be pressed for a short time to expel excess whey. It is then kneaded by hand and finally pressed into small cylindrical shapes 1¾ by 2¾ inches, weighing one-fourth pound each. These are wrapped in parchment paper and tinfoil, and are then ready for market.

Qualities of Neufchatel cheese.—Neufchatel cheese should have a distinct, mild, clean flavor resembling well-ripened cream. The texture should be fairly dry, yet smooth and entirely free from lumps. There should be no leaking whey, and each cheese should be neatly wrapped. The cheese will usually keep in good condition for two weeks if kept in a cold place. From 100 pounds of milk about 22 pounds of Neufchatel cheese can be made, which sells for 20 to 40 cents per pound, depending on its quality and the manner of marketing.

Precautions to observe in making Neufchatel cheese.—The making of Neufchatel cheese is easy and very profitable, but in order to secure a uniformly good product each day strict attention must be given to the control of temperature, acidity, and moisture. High temperature, too much rennet, too much acid, too rapid drying and uneven drying, all cause lumpy texture. It is very important that the curd be properly coagulated before being placed in the draining process. If it is too soft, or breaks up too much in being transferred from the can to the strainer, uneven drying usually results.

J. Michels, of the North Carolina Station, states that American methods of making Neufchatel cheese are unsatisfactory because they are too slow, the souring process is not properly controlled with a consequent lack of uniformity of product, and the product is not properly packed. A method of procedure which he found was not subject to these objections is as follows:

Whole milk reenforced with an amount of cream equal to about one-quarter that in the whole milk makes the best Neufchatel cheese. However, whole milk without the addition of cream will make a very satisfactory cheese. It is of first importance to use only milk which is clean and free from taints.

When the cheese is made on a small scale, common cans of the shotgun style will answer for handling the milk. Where several hundred pounds of milk are used a small milk or cream vat may be used. A strainer with perforated sides and bottom is also needed to drain the curd. * * *

The milk should be treated with a large amount of starter or pure culture of lactic-acid bacteria. On an average, 1 pound of starter to 4 pounds of milk will give best results. During warm weather when the milk has already ripened somewhat, and when there naturally is a more rapid development of lactic acid, one part of starter to five of milk will be about right. On the other hand, during cold weather or when the milk is very sweet, it is best to use at the rate of one part starter to three parts of milk. Thoroughly beat or shake the starter and strain it through one thickness of cheesecloth before adding it to the milk.

As soon as the starter has been added, heat the milk to 80° F. and add at the rate of 2½ ounces of commercial rennet extract per 1,000 pounds of milk. The rennet extract should be diluted with water to the extent of about eight times its own volume and then thoroughly mixed with the milk. The mixing should not be continued for more than three minutes. This precaution is necessary, as the milk begins to thicken in about five minutes. Cover the milk and allow it to stand quietly for 30 to 60 minutes, according to the amount of starter used. The more starter used the quicker the milk will curdle.

While the milk will usually be ready to cut in from 30 to 60 minutes, it is best to determine when this point is reached, as for Cheddar cheese, by breaking the curd with the forefinger. If the whey in the break is clear, the curd is ready to cut; if milky, the curdling has not progressed far enough. In general, the curd should be somewhat firmer than for Cheddar cheese before cutting.

Where much cheese is made, the curd is cut with special knives used with Cheddar cheese. The cutting in this case is done as follows: First cut the curd in horizontal layers with the horizontal knife; next cut lengthwise, and then crosswise with a perpendicular knife. This will make cubes about one-half inch on a side. Where small quantities of cheese are made any kind of a knife may be used to cut the curd. The smaller the amount of milk used, the coarser the curd should be cut.

As soon as the curd is cut it is carefully poured into a tin strainer lined with one thickness of cheesecloth. Both the sides and bottom of the strainer should be perforated. It should be about 10 inches deep and of such width and length as to permit filling it the full depth. Allow the curd to drain undisturbed for about one hour and then put a cover, preferably a metallic one, on it and add pressure at the rate of 1 pound for every gallon of milk used. During the next hour gradually increase this pressure until 5 pounds are used for every gallon of milk. Continue this amount of pressure for eight hours and then reduce to 2 pounds for every gallon of milk and keep at this pressure 12 hours longer, when the curd is ready to salt.

Salt at the rate of about 1 ounce of salt to 6 pounds of cheese. The salt can be evenly distributed during the mashing process.

With a heavy masher, similar to a potato masher, thoroughly mash the curd to a smooth consistency, leaving no unbroken particles or lumps. The smoother the curd the richer it will appear and the better it will taste.

A variety of packages may be used in which to pack the cheese. The common method of packing is to wrap the cheese first in parchment paper and then in tinfoil. This method of packing is especially suitable where cheese is made on a small scale. Such a package is open to the objection, however, that it does not sufficiently exclude the air to prevent molding.

The best package is one in which the cheese can be kept as nearly air tight as possible. We have found a tin-capped tumbler the most satisfactory. The only objection to the tumbler is the expense when purchased in small quantities. In large quantities 8-ounce tumblers may be purchased very cheaply.

The tumblers and the parchment caps which are put under the tin caps should be sterilized in boiling water before using. With a large spoon pack the tumbler brimful, place a parchment paper cap on top, and then cover with the tin cap. The parchment cap should project about one-quarter inch over the edge of the tumbler. Cheese packed in this way will keep 10 days during warm weather without refrigeration.

In making Neufchatel cheese as herein described a good starter is indispensable. It will pay well to give the starter careful attention. Use attractive labels on the tumblers. They cost little, but will help sell the cheese at a better price. While the cheese can be kept some time without refrigeration, it is best to keep it in as cool a place as possible, such as a cellar.

Prof. Michels thinks that Neufchatel cheese packed in 8-ounce tumblers should readily sell at 10 cents per tumbler net, and at this price will yield a good return to the producer and furnish the consumer a wholesome and digestible food at a very reasonable cost. One hundred pounds of milk containing 4 per cent of fat will yield thirty-four 8-ounce tumblers of cheese. When such milk is reenforced with cream as suggested above, 100 pounds of it will yield 38 tumblers of cheese.

[A list giving the titles of all Farmers' Bulletins available for distribution will be sent free upon application to any Member of Congress or the Secretary of Agriculture.]

Issued April 15, 1911.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 436.

WINTER OATS FOR THE SOUTH.

BY

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Bureau of Plant Industry.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., December 31, 1910.

SIR: I have the honor to transmit and to recommend for publication as a Farmers' Bulletin the accompanying manuscript, entitled "Winter Oats for the South," prepared by Mr. C. W. Warburton, Agronomist in Charge of Oat Investigations, under the direction of Mr. W. A. Carleton, Cerealist in Charge of Grain Investigations.

The growing of winter grains is an important part of the diversification of crops in the South. Winter oats is one of the best of the winter grains for general use, but under ordinary methods of culture the crop frequently winterkills or returns unsatisfactory yields. Methods are described in this bulletin by which the loss from winterkilling may be largely obviated and the yields materially increased. It is believed that this information will be of general interest to southern farmers.

Respectfully,

WM. A. TAYLOR,
Acting Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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WINTER OATS FOR THE SOUTH.

INTRODUCTION.

Some of the problems in the production of winter oats in the Southern States are quite different from those which must be solved by the grower of spring oats in the northern and central portions of the United States. Not only are the varieties different, but the proper selection of soils and fertilizers and the time and manner of seeding to secure the best results in the production of the crop are quite at variance with the best practices in the sections where spring oats are extensively produced. The methods of growing spring oats and the uses which can be made of the oat crop have been discussed in previous publications.[a] In this bulletin it is proposed to outline the best methods for the production of winter oats in the Southern States.

PRODUCTION OF OATS IN THE SOUTHERN STATES.

The production of winter oats is more or less practicable throughout the sections usually known as the South Atlantic and South Central States, which, for convenience, will be referred to in this publication as the Southern States, although they include some to which that term is not usually applied. In these States the production of oats averaged a little more than 74,000,000 bushels for the ten years 1900–1909. The Bureau of Statistics of the Department of Agriculture does not report the acreage of winter and spring oats separately, so it is impossible to estimate the proportion of the two crops. The annual production in the United States for this period averaged

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[a] Farmers' Bulletins 424, entitled "Oats: Growing the Crop," and 420, "Oats: Distribution and Uses." Farmers' Bulletin 395, entitled "Sixty-Day and Kherson Oats," discusses two varieties of spring oats adapted to the corn belt. Circular 30, Bureau of Plant Industry, entitled "Improvement of the Oat Crop," outlines methods for improving oats, with the details of a plan for testing individual selections. All these publications will be sent free of cost upon request to the Secretary of Agriculture, Washington, D. C.

870,000,000 bushels, so that about 8.5 per cent of the crop was produced in the South. During these ten years the average area devoted to oats in the United States was nearly 30,000,000 acres, of which 3,400,000 acres, or about 11.5 per cent, were in the South. The average yield to the acre was only 21.8 bushels, as compared with 29.5 bushels for the entire country, which shows why the South produced only 8.5 per cent of the crop on 11.5 per cent of the area. Owing to the high price per bushel, 46.4 cents, as compared with 35.5 cents for the entire United States, the acre value, $10.09, was little less than that for the entire country, $10.26.

The acreage, production, and value of oats in each of the Southern States for the ten years 1900–1909 are shown in Table I.

TABLE I.—*Average acreage, production, and value of the oat crop in the Southern States for the ten years 1900–1909, inclusive.*

State.	Acreage.	Yield per acre.	Production.	Price per bushel on Dec. 1.	Total farm value on Dec. 1.	Value per acre on Dec. 1.
	Acres.	*Bushels.*	*Bushels.*	*Cents.*		
Delaware	5,554	25.3	134,244	42.8	$54,693	$10.96
Maryland	38,778	25.1	961,902	41.1	381,427	10.32
Virginia	209,237	17.6	3,598,184	44.8	1,603,720	7.93
West Virginia	94,735	22.1	2,082,669	45.1	926,602	9.91
North Carolina	226,458	14.8	3,325,908	53.6	1,767,868	8.00
South Carolina	209,212	17.1	3,564,592	61.9	2,226,572	10.75
Georgia	291,986	15.3	4,500,511	60.3	2,755,622	9.33
Florida	31,196	13.5	421,248	64.5	273,872	8.82
Alabama	225,032	15.6	3,509,503	57.6	2,038,473	9.05
Mississippi	116,685	16.7	1,914,119	56.2	1,081,705	9.38
Kentucky	239,696	21.0	5,053,044	41.6	2,000,321	8.60
Tennessee	188,094	19.4	3,588,663	43.7	1,557,242	8.54
Arkansas	215,173	20.0	4,278,428	47.0	1,948,183	9.34
Louisiana	31,042	16.9	523,677	51.2	268,463	8,65
Oklahoma [a]	480,303	29.4	13,872,095	37.7	5,202,283	10.58
Texas	798,442	27.8	22,712,303	48.2	10,242,235	12.71
Average for total area	3,401,623	21.8	74,041,090	46.4	34,329,281	10.09

[a] The figures for Oklahoma are for nine years, 1901–1909, inclusive, and include Indian Territory previous to its admission as a State.

Table I shows that Texas and Oklahoma were the leading States in acreage, production, total value, and in yield to the acre. These two States produced nearly as many bushels of oats as all the other Southern States together. Kentucky, Georgia, and Arkansas each produced more than 4,000,000 bushels annually, while most of the other States ranged from 2,000,000 to 3,500,000 bushels each. Virginia, North Carolina, South Carolina, Alabama, Kentucky, Tennessee, and Arkansas each devoted about 200,000 acres annually to this crop, while Georgia grew oats on nearly 300,000 acres. The average yield to the acre in most of the States was below 20 bushels; in North Carolina and Florida it was less than 15 bushels. The price per bushel was high in most of the States, ranging from 38 to 45 cents in the northern portion of the area and from 50 to 65 cents in the southern part. In some of the States where the yield fell below 20 bushels the acre value was as high as in some of the Northern States where the average yield was 30 bushels to the acre.

The acreage and acre value of oats, corn, and wheat in each of the Southern States for the ten years 1900–1909, inclusive, are shown in Table II.

TABLE II.—*The average acreage and acre value of oats, corn, and wheat in the Southern States for the ten years 1900–1909.*

State.	Acreage.			Value per acre.		
	Oats.	Corn.	Wheat.	Oats.	Corn.	Wheat.
	Acres.	*Acres.*	*Acres.*			
Delaware	5,554	193,450	111,762	$10.96	$14.64	$13.59
Maryland	38,778	637,704	781,849	10.32	17.34	13.57
Virginia	209,237	1,867,272	754,172	7.93	13.51	9.62
West Virginia	94,735	765,775	378,196	9.91	17.33	10.34
North Carolina	226,458	2,689,974	605,243	8.00	10.28	8.33
South Carolina	209,212	1,910,032	296,181	10.75	8.99	9.37
Georgia	291,986	4,077,388	320,093	9.33	8.48	9.28
Florida	31,196	611,961	....	8.82	7.59	....
Alabama	225,032	2,874,325	103,888	9.05	9.29	9.87
Mississippi	116,685	2,100,916	2,598	9.38	10.15	9.42
Kentucky	239,696	3,213,352	804,941	8.60	13.53	9.94
Tennessee	188,094	3,194,754	927,750	8.54	12.49	8.72
Arkansas	215,173	2,406,448	220,315	9.34	10.59	8.15
Louisiana	31,042	1,532,515	....	8.65	10.10	....
Oklahoma	480,303	3,980,448	1,441,832	10.58	9.95	9.16
Texas	798,442	6,400,478	989,875	12.71	10.73	9.34
Average for total area	3,401,623	38,456,792	7,738,695	10.09	11.02	9.70

Table II shows that the average acreage of corn in the Southern States for the ten years 1900–1909, inclusive, 38,456,792 acres, was about eleven times that of oats, while the average acreage of wheat, 7,738,695 acres, was more than double that of oats. The corn acreage in each of the States was usually from ten to twelve times that of oats. In four of the States, Alabama, Mississippi, Florida, and Louisiana, the oats acreage exceeded the wheat acreage, while in Georgia and Arkansas it was but little smaller. In Texas, Oklahoma, Delaware, Maryland, and South Carolina the acre value was more than $10. In South Carolina, Georgia, Oklahoma, and Texas the acre value was greater than that of either wheat or corn; it was greater than that of corn in Florida and greater than that of wheat in Arkansas. No figures were reported for wheat in Florida and Louisiana.

VALUE OF A WINTER GRAIN CROP IN THE SOUTH.

Farm conditions in the South can be improved by the use of a greater variety of crops and of definite systems of crop rotation and by the keeping of a greater number of live stock. A rational crop rotation in the South is one which occupies the land practically the entire year, protecting the soil from washing during the winter by the use of a growing crop, such as crimson clover, vetch, or winter grain. Increasing the number of live stock requires the production of more grain for feeding. Winter grains combine the two essential features, grain production and soil cover, in one crop. Within reasonable limits they supply a third desirable feature, winter pasture. On the other hand, spring-grain production in the greater portion of the Southern States is far from certain. Winter varieties of wheat and barley have almost entirely replaced the spring types of these grains, so that the only spring-grain crop now generally sown in the South is oats.

FALL-SOWN COMPARED WITH SPRING-SOWN OATS.

The advantages of fall seeding of oats over spring seeding wherever the winter varieties can be grown are numerous. The yields are usually better, the fall-sown oats mature earlier, the land can usually be prepared in better shape in the fall than in the spring, fall seeding interferes less with other work than does spring seeding, poorer land and less fertilizer can be used for the fall-sown crop, and the fall-sown crop furnishes a cover for the soil during the winter and prevents washing.

Winter oats almost invariably yield more than spring oats, owing to their earlier maturity, stronger growth, and greater freedom from disease. If a part of the stand is lost from winterkilling, the plants which are left stool vigorously, so that the stand at harvest is much better than was apparent in early spring. Fall-sown oats usually grow more vigorously and mature from ten days to two weeks earlier than those sown in the spring. This earlier maturity often marks the difference between success and failure, as the later maturing grain is more likely to be injured by storms or drought and by rust and other plant diseases. Oats require comparatively cool weather for their best growth, so that those which mature earliest usually yield best, as the conditions are better suited to their development. The early maturity incident to fall seeding also allows the crop to be removed from the land earlier than spring seeding, giving more time for the preparation of the soil, seeding, and the growth of the following crop.

In a seven-year test at the Alabama Agricultural Experiment Station, in which November and February seedings were compared, the fall-sown oats yielded 26.8 bushels to the acre, while the spring-sown yielded only 15.5 bushels. The gain in favor of November seeding was 11.3 bushels, or 73 per cent of the spring-sown crop. The spring-sown oats outyielded the fall-sown in only one year of the seven, when 25 per cent of the fall-sown crop winterkilled. At the Arkansas station three varieties of fall-sown oats yielded 75 per cent more than the average of twenty spring-sown varieties. The best-yielding varieties of fall-sown oats yielded more than 40 bushels to the acre, as compared with more than 30 bushels for the best of the spring-sown kinds. At the Virginia station, in a two-year test, fall-sown Culberson oats yielded 27.8 bushels to the acre, while the best of the spring varieties—the Silvermine—yielded 27.2 bushels. Better yields have also been secured at the Georgia station and at the Edgecombe (North Carolina) branch station from fall than from spring seeding.

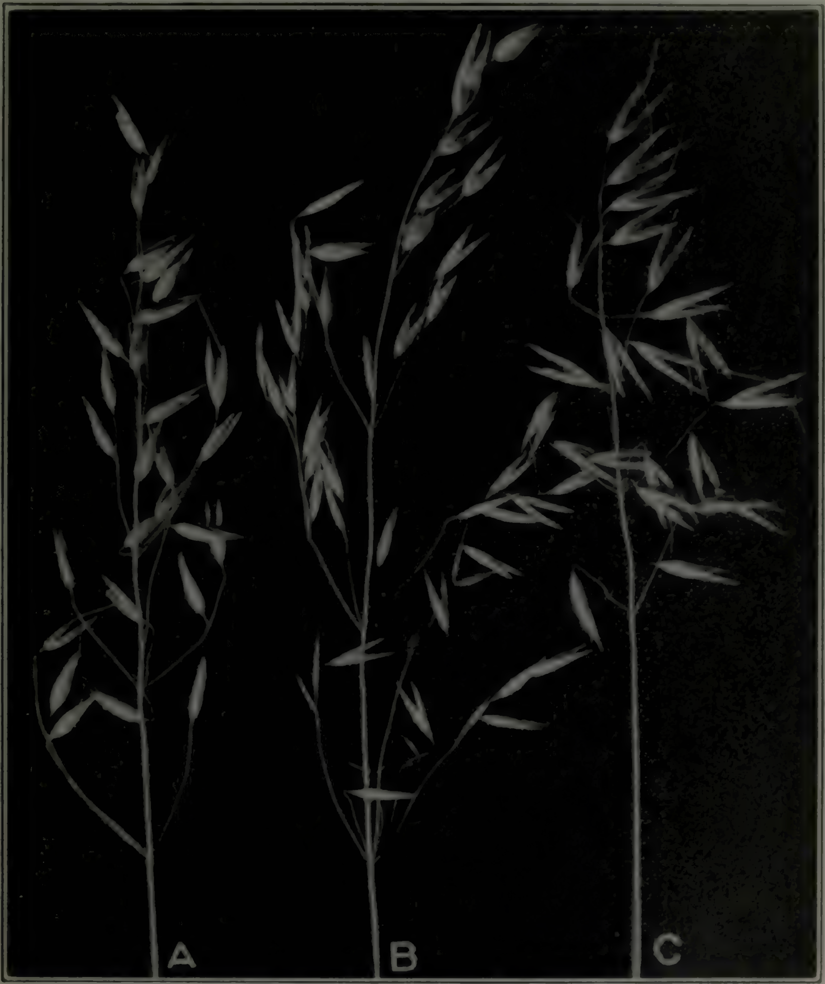

FIG. 1.—Heads of three varieties of winter oats. A, Winter Turf; B, Culberson; C, Red Rustproof.

In order to obtain a satisfactory crop of spring oats it is necessary in the extreme South to sow the grain in January or early in February, and in February or early March farther north. At this time the ground is usually wet and cold and is not in condition to make a good seed bed. Clay soils may be materially injured by working them when wet, and only very sandy ones can be handled satisfactorily in this condition. On the other hand, at the time when the grain should be sown in the fall the ground is ordinarily in good condition to work, and a good, mellow seed bed can be prepared. This better preparation starts the young plants into vigorous growth and they go into winter in good shape. Seed sown in the winter or early spring on poorly prepared land is handicapped by this poor preparation, grows slowly, and is never as vigorous as that sown in a good seed bed.

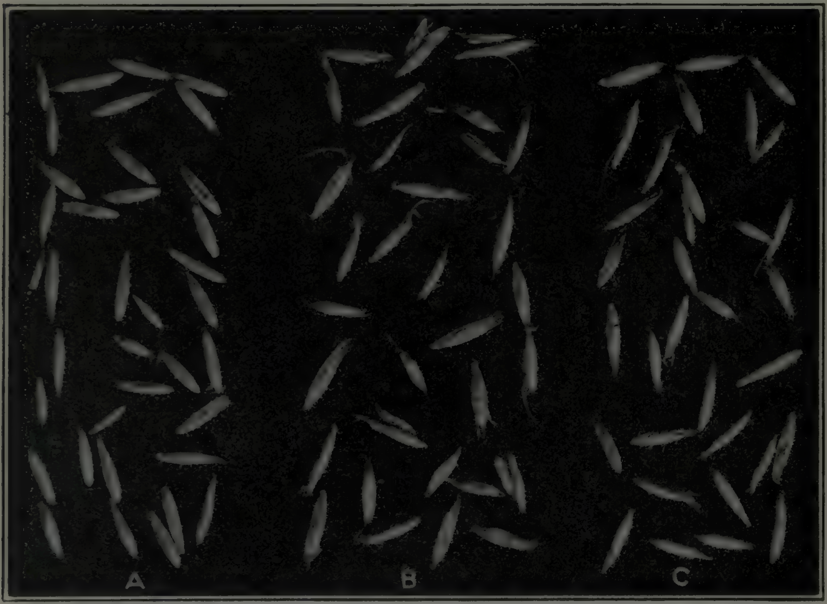

FIG. 2.—Grains of three varieties of winter oats. A, Winter Turf; B, Culberson; C, Red Rustproof.

When weather and soil conditions are right for preparing land in the spring, teams and men are needed to get the land ready for the more important crops, corn and cotton; consequently the preparation of the land for sowing oats is hurried or neglected. Fall seeding comes at a time when the teams are not needed for other work, and there is more time to do the work properly. It allows a better division of the farm work, so that more time can be given to preparing the land in the spring for other crops. If the fall-sown crop of oats fails, little additional work is necessary to put the land in shape for reseeding in the spring.

As the plants have a longer time to draw the plant food from the soil, and as they naturally grow more vigorously, fall-sown oats can be grown on poorer ground and with less fertilizer than those sown in the spring. Good soil and proper fertilization have much to do with the success of the oat crop in the South, however, regardless of the time of seeding.

One of the greatest losses on southern farms is from the washing of the soil during the winter. This can best be prevented by growing a crop on the land. Winter oats make a close, dense cover, which is very effective in holding the surface soil to prevent washing.

The foregoing are some of the reasons why it is desirable to sow oats in the fall in the South wherever there is a reasonable chance that they will withstand the winter. It is believed that proper methods of soil preparation and of seeding, and the use of plump, heavy seed of hardy, productive varieties, will largely increase the production of this grain. The methods described in this bulletin are in use by the agricultural experiment stations and by good farmers.

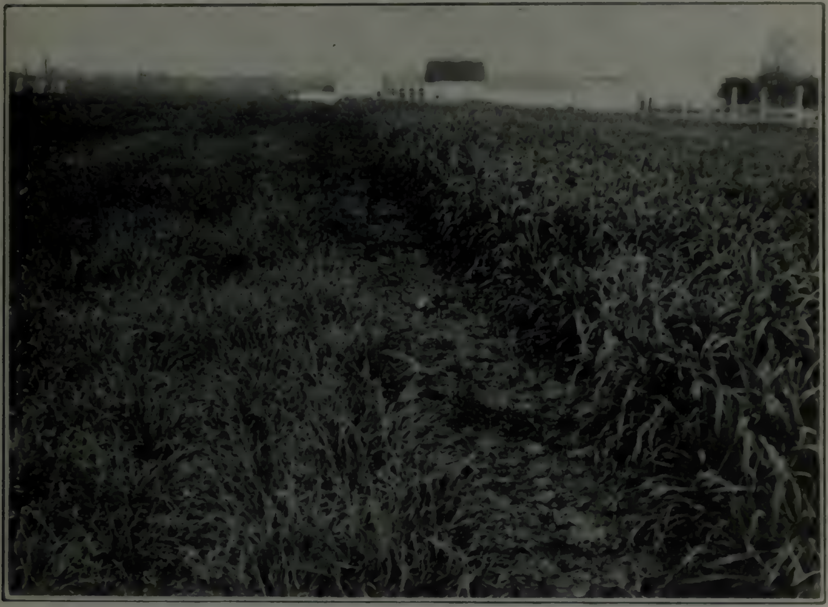

FIG. 3.—Plats of winter oats in November at the Maryland Agricultural Experiment Station, College Park, Md. Note the broad leaves and erect habit of the Red Rustproof variety (on the right) in contrast with the narrow leaves and spreading habit of the Winter Turf (on the left).

VARIETIES OF WINTER OATS.

The varieties of winter oats commonly grown in the South are of one or the other of two types, the Red Rustproof and the Winter Turf. The Red Rustproof type includes the common Red Rustproof under several similar names and several selections and strains of that variety under entirely different names. Only one variety of the Winter Turf type is commonly grown, though many names are applied to it.

Red Rustproof is the typical variety of the group to which that name is here applied. Among the other names used for the same variety are Red, Texas Red, Red Texas, and Texas Red Rustproof. The leaves of the young plant in the fall are medium green in color and rather broad. The plant, while spreading, is less so than most other winter grains. The straw of this variety is of medium height, straight and stiff. The heads are not large, but numerous. The grains are large and plump, yellowish or reddish brown in color, and usually all awned. The Red Rustproof is early in maturing and is quite free from rust. As commonly grown in the South, this variety contains a small percentage of black kernels which produce plants maturing earlier than the type. When grown by itself this black strain yields much less than the pure Red Rustproof. Seed of the Red Rustproof also usually contains some medium-sized white kernels, producing strong plants and large heads which mature at about the same time as those from the red grains. The Culberson variety, as it is commonly grown, appears to be a selection of this white type, though occasionally oats sold under this name can not be distinguished from the common Red Rustproof. The Culberson oat yields as much grain as the Red Rustproof, produces more straw, and is a better

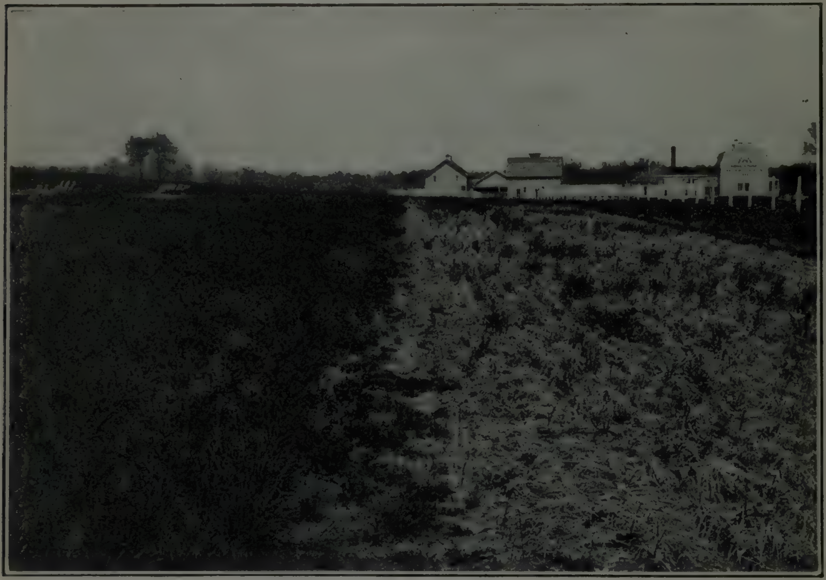

FIG. 4.—The same plats shown in Fig. 3, photographed the following spring, showing the winterkilling of the Red Rustproof in contrast with the survival of the Winter Turf variety.

variety to grow for hay or soiling. The Appler is a strain of Red Rustproof selected by Mr. J. E. Appler, of Georgia, a number of years ago. All the varieties of this type may be sown either in the fall or spring.

The Winter Turf oat, which is also called Virginia Gray, Virginia Winter, Grazing, and several similar names, is better adapted to pasture and hay than to grain production. The leaves are narrow, dark green in color, and numerous; the plant is more spreading in the fall than that of the Red Rustproof variety. The straw is tall and slender and the heads large and loose. The grain is of medium size, usually light gray in color, bearded or beardless; the beards, when they do occur, break off readily in thrashing. This variety is not resistant to rust or lodging. The numerous names applied to it may sometimes denote distinct strains, which, however, differ but little from the type. The Dun and the Oregon Gray Winter varieties are very similar to the Winter Turf. Heads of the Red Rustproof, Culberson, and Winter Turf varieties are shown in figure 1, while grains of these varieties are shown in figure 2.

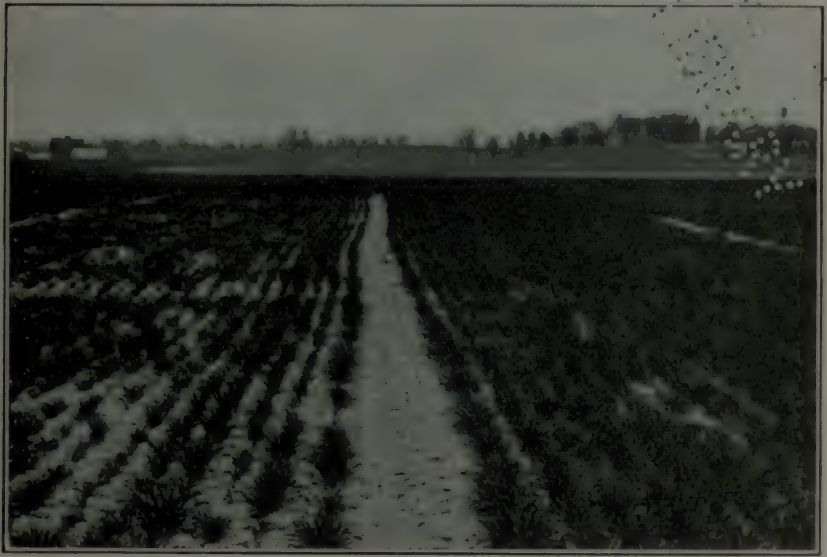

FIG. 5.—Plats of the Winter Turf (on the right) and the Culberson (on the left) varieties of oats at the Maryland Agricultural Experiment Station, College Park, Md., on March 20, showing the difference in winter survival.

Among the other varieties which are occasionally sown in the fall is the Burt, sometimes called the Ninety-Day or May. This variety is quite similar to Red Rustproof, but is less hardy. It is ordinarily sown in the spring, as it usually does well from spring seeding. In Utah a black oat, known locally as Boswell Winter, is grown to some extent on the dry farms. Black Winter oats are also grown in Oregon and Washington. The oats commonly grown in California are Red Rustproof.

The varieties of the Red Rustproof type are best adapted to the production of grain in all except the coldest portions of the winter-oat belt, where Winter Turf is to be preferred on account of its greater hardiness. In the sections where Red Rustproof is sufficiently hardy, the Winter Turf is rather too late in maturing and is often injured by hot weather, producing low yields of poor quality. For pasture and hay production Winter Turf is better than either Red Rustproof or Culberson. Figure 3 shows the differences in the fall growth of the Winter Turf and the Red Rustproof, while figure 4 shows the relative hardiness of these two varieties following a severe winter. Figures 5 and 6 show comparative stands of Culberson and Winter Turf in early spring and at harvest time.

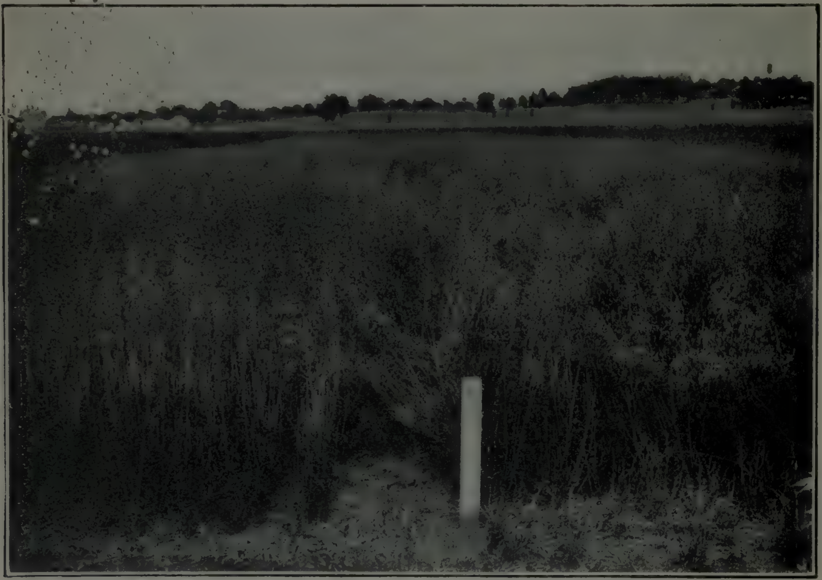

FIG. 6.—Plats of Winter Turf and Culberson oats shown in Fig. 5, at harvest time. Note the manner in which the Culberson variety (on the left) has stooled, forming a good stand; also its erect habit in contrast with the tendency to lodge shown by the Winter Turf oats.

SECTIONS WHERE WINTER OATS CAN BE GROWN.

No definite limits can be drawn marking the sections where winter oats can or can not be grown. The variety, the method of preparation, the time and manner of seeding, the kind of land on which the crop is grown, and the climatic conditions of the particular section must all be taken into account. Varieties of the Winter Turf type can be grown in colder sections than those of the Red Rustproof type. Oats sown early in drills or furrows on well-prepared land often survive the winter in the same locality where those sown under less favorable conditions winterkill. Winter oats may be successfully grown in a particular section for several years; a season may then come when the crop will be entirely destroyed by cold or other unfavorable conditions.

The accompanying map (fig. 7) shows approximately the sections in which winter oats can be grown with a reasonable degree of success. The crop is recommended for South Carolina, Georgia, Alabama, Florida, Mississippi, and Louisiana; Virginia and North Carolina, except the highest mountain sections; the lower portions of Maryland, Tennessee, and Arkansas; and for eastern, central, and southern Texas. It is worthy of trial in southern Delaware, in favorable locations in West Virginia and Kentucky, in northern Arkansas, and in Oklahoma and the portions of Texas not previously mentioned. Winter oats are also grown to a limited extent in Utah, Oregon, and Washington. In California and in some portions of Arizona and New Mexico oats are sown in the late fall or early winter. Winter oats have also been grown with success experimentally in Connecticut, Ohio, and southern Michigan, but can not yet be recommended for these or similar localities. It is probable that the

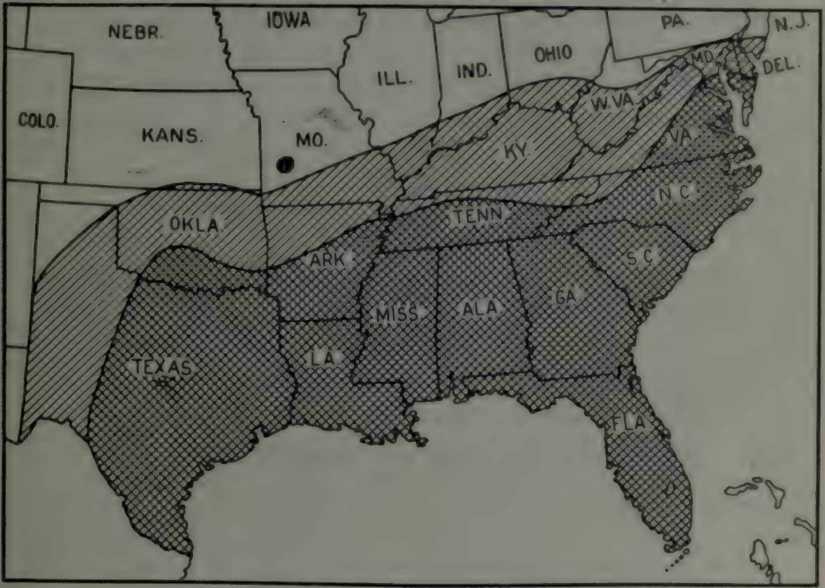

FIG. 7.—Map of the southeastern portion of the United States, showing area to which winter oats are adapted. The heavily shaded portion shows the section where they are a comparatively sure crop; the section where they are worthy of trial is shown by lighter shading.

winter-oat area will gradually extend northward, but the spring-sown crop is not likely to be displaced in the corn belt. The discussion of the crop in this bulletin is confined to the Southern States.

SOILS AND FERTILIZERS FOR OATS.

SOILS ADAPTED TO OAT PRODUCTION.

As quick growth and early maturity are essential to the success of the oat crop in the South, the soils and fertilizers which will produce these results should be selected.

The soil for oats should be reasonably fertile and should hold moisture well, as this crop requires a large amount of water and may be severely injured by drought. Any soil which will grow a good crop of cotton or corn will produce oats, though the best results will be secured on the heavier loams. Heaving, or the " spewing out " of the plants, is most likely to occur on clay soils, particularly on those deficient in humus. A well-fertilized sandy or sandy-loam soil will generally prove more satisfactory, particularly if it is well filled with humus, so that its moisture-holding capacity is high. Good drainage is essential, however, as winterkilling is most likely to occur on poorly drained land. Rust and other diseases are also most severe on low, poorly drained areas. As the varieties of oats commonly grown in the South, with the exception of the Winter Turf, have short, stiff straw, they are less likely to lodge on rich soil than those grown in the North.

MANURES AND COMMERCIAL FERTILIZERS.[a]

A good crop of oats removes nearly as much nitrogen, phosphoric acid, and potash from the soil as a good crop of corn. Nitrogen (ammonia) can be supplied in nitrate of soda, dried blood, cottonseed meal, or other commercial forms, or by growing a leguminous crop, such as cowpeas, soy beans, or clover. Potash is usually applied in the form of the muriate, and phosphoric acid in acid phosphate. The quantity of all the fertilizing materials needed, of course, depends largely on the nature and the fertility of the soil. Barnyard manure is not usually available in sufficient quantity to be much of a factor in keeping up the fertility of the soil.

Green Manures.

The best and cheapest method of adding nitrogen is by growing a green-manure crop, which gathers nitrogen from the air and stores it in the soil. Green manures also supply humus or vegetable matter, which is usually lacking in southern soils. The crop most commonly used for this purpose in the South is cowpeas, though crimson clover, vetch, velvet beans, bur clover, peanuts, and red clover are among the others which are available. Cowpeas and soy beans are among the best available crops to immediately precede oats. Velvet beans are also excellent, but can not be grown profitably except in the Atlantic and Gulf coastal plain regions from South Carolina southward. These crops may be cut for hay, turning under only the stubble and roots, or the entire crop may be used as green manure. The fertilizing effect on the following crop is about the same whether the stubble or the entire plant is turned under, but the vines add considerable humus and improve the physical condition of the soil. If the vines are turned under, the land should be plowed three or four weeks before the oats are to be sown, as the ground should have time to settle before seeding. If the oats must be sown at once after the land is prepared, it is better to harvest the vines and disk the land thoroughly instead of plowing it.

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[a] An extended discussion of fertilizers, with tables showing the best quantities of the various materials to apply for oats and for other crops on the different soils of the South, is contained in Farmers' Bulletin 398, entitled "Farm Practice in the Use of Commercial Fertilizers in the South Atlantic States."

Barnyard Manure.

Barnyard manure is an excellent fertilizer for almost all crops, as it contains all the elements of plant food and a considerable quantity of humus as well. One of the best methods of using barnyard manure on oats in the South, where it is seldom available in large quantities, is as a top-dressing applied in the late fall or early winter. When so applied it serves as a protection to the crop during the winter and at the same time adds fertility to the soil. It is probable that the largest increase to the ton of manure will result from the application of about 5 tons to the acre.

Commercial Fertilizers.

If nitrogen has been supplied in liberal quantities through the growth of legumes as green manures, it need not be added in commercial fertilizers. If, however, a green-manure crop does not immediately precede the oats, or if the preceding crop was light, some readily available fertilizer carrying nitrogen (ammonia) should be used. The best results on most classes of soil are to be obtained by adding this nitrogen as a top-dressing in the spring, about two months before harvest. The nitrate should be sown broadcast and worked into the soil with a harrow. Cottonseed meal or dried blood may be used to supplement the nitrate of soda. On sandy soils the application of about 25 pounds of nitrogen (50 pounds of nitrate of soda and 200 pounds of cottonseed meal or 100 pounds of dried blood) to the acre is recommended.

On clay soils this may be reduced to 18 or 20 pounds of nitrogen (30 pounds of nitrate of soda and about 150 pounds of cottonseed meal). If the oats are grown for hay, more nitrogen should be used than when they are grown for grain. A much larger increase in yield of grain per hundred pounds of nitrate of soda applied was obtained at the Alabama station from the use of 100 pounds or less to the acre than from 200 pounds, though 200 pounds gave a greater total yield than 100 pounds. A bulletin of this station states that a profit of from $4 to $6 can be expected from the application of 60 to 100 pounds of nitrate of soda to fall-sown oats. Cottonseed meal is recommended as being a better fertilizer for oats than cotton seed.

If the soil has been liberally fertilized for other crops, phosphoric acid and potash need not be added for oats. Usually, however, increased yields result from light applications of acid phosphate and muriate of potash at the time of seeding. The proper quantity of acid phosphate to apply varies from 100 to 125 pounds to the acre on fertile clay soils to 200 to 250 pounds on the poorer sandy soils. The rate for muriate of potash varies from 30 pounds on the better clay soils to 60 pounds on poor sandy ones. Nitrogen, however, is usually the limiting element in the production of oats on southern soils.

The Georgia station recommends the application of 200 pounds of acid phosphate, 50 pounds of muriate of potash, 25 pounds of nitrate of soda, and 200 pounds of cottonseed meal when the grain is sown, and of 75 pounds of nitrate of soda in the spring. Where cowpeas or similar crops have been grown the nitrate of soda and cottonseed meal to be applied in the fall may be omitted, making the application 200 pounds of acid phosphate and 50 pounds of muriate of potash in the fall and 75 pounds of nitrate of soda in the spring. This quantity may be somewhat increased for poor sandy land and decreased for fertile loam and clay soils. On the heavy "black waxy" soil of Texas it is probable that both the phosphate and potash may be omitted, and only the nitrate of soda added in the spring. On this soil the use of barnyard and green manures to supply humus is particularly to be recommended.

LIMING THE SOIL.

Liming is not usually beneficial to oats, but may be of value in correcting the acidity of sour soils, particularly where heavy green-manure crops have been plowed under. Lime is most beneficial to the growth of clover, alfalfa, and other legumes, so that the best results are usually obtained when it is added before growing one of these crops. The application of from 25 to 40 bushels of lime or from 1 to 2 tons of finely ground limestone to the acre is usually sufficient to correct the acidity of the soil for five years or more. Where heavy green-manure crops are plowed under every year, more frequent applications of lime may be necessary.

WINTER OATS IN THE ROTATION.

Oats should follow a cultivated crop wherever possible. The most common cultivated crops in the South are cotton and corn, and, as corn is removed from the land earlier than cotton, oats usually follow the former. One of the best rotations which can be devised for the cotton-growing section is as follows: First year, cotton; second year, corn, with cowpeas planted at the last cultivation; third year, winter oats, followed by cowpeas.

This rotation is strongly recommended by the Georgia station. The corn is cut for fodder, instead of being stripped and topped, as is commonly done in some sections; the corn stubble and cowpea vines are then turned under in time to sow oats in the fall. As the growth of pea vines is not heavy, the plowing can be done a short time before seeding. After the oat crop is removed the third year, the land is plowed and planted to cowpeas, which are cut for hay. If desired, crimson clover may be sown in the cotton the first year and plowed under in the spring before corn-planting time. Rye may also be sown the third year after the cowpeas and plowed under for cotton, thus providing a cover for the soil each winter. This rotation gives two grain crops, corn and oats; a money crop, cotton; a hay crop, cowpeas; and three green-manure crops, crimson clover, cowpeas planted in the corn, and rye, in three years. Two crops of cotton may be grown in this rotation, if desired, making a four-year rotation.

Outside the cotton-growing section a good rotation, including oats, is as follows: First year, corn, with cowpeas in the corn; second year, oats, with clover or grass seeded in the oats; third year, meadow or pasture.

If it is desired to grow wheat, oats may be sown after the corn and cowpeas planted after the oats are harvested. Wheat may then be planted after the cowpeas and grass seeded with it. Potatoes or other cultivated crops may be substituted for corn if desired. Where clover does not succeed, or where a permanent meadow is not wanted, the following rotation is a good one: First year, corn, with cowpeas in the corn; second year, wheat, followed by cowpeas, which are cut for hay; third year, oats, followed by cowpeas, sorghum, or some other forage crop.

If desired, rye may be sown after the forage crop is harvested, or the forage crop may be omitted and crimson clover sown early in the fall. The rye or crimson clover is then plowed under the following spring for corn. Other rotations along similar lines can be arranged, according to the crops it is desired to grow.

The value of a leguminous crop preceding oats is well shown by experiments at the Alabama station. The yield after corn was 13.7 bushels to the acre; after cowpeas plowed under, 19.9 bushels; and after peanuts from which the nuts had been picked, 30 bushels. In another experiment the yield after millet was 9.7 bushels; after crab-grass and weeds, 7.1 bushels; after velvet beans, stubble only, 38.7 bushels; after velvet beans, vines plowed under, 28.6 bushels; after cowpeas, stubble only, 34.4 bushels; and after cowpeas, vines plowed under, 28.8 bushels. The average yield after nonleguminous plants was 8.4 bushels, while after leguminous plants it was 32.6 bushels, with a corresponding difference in the yield of straw. These figures, however, are the results of only one year's work. A large part of the benefit could, no doubt, have been secured by growing oats after a cultivated crop in a short rotation which included two or more leguminous crops.

PREPARATION OF THE LAND FOR OATS.

The method of preparation of the land depends to some extent on the previous treatment it has received and on the character of the soil. In any case a loose, mellow seed bed should be prepared, as the success of the crop depends in a large measure on the condition of the seed bed and on the fall growth.

In general, the land should be plowed 5 or 6 inches deep at least a month before the oats are to be sown, and the plow followed immediately by the spike-tooth or other smoothing harrow. Double disking and another harrowing should then put it in shape for drilling. Additional disking and harrowing may be necessary, if the ground is hard and rough. If it is loose from recent plowing, the roller or plank drag may be used to make a more compact seed bed. Rolling may often be done to advantage on loose, sandy land, but on the heavier loam and clay soils the roller should always be followed with the harrow to break the crust and check evaporation. If the land has been thoroughly plowed the preceding spring for some other crop and has been thoroughly cultivated throughout the season, disking and harrowing may take the place of plowing, especially on sandy land. The fertilizer may be distributed when the seed is sown if the oats are to be drilled; otherwise, it should be applied before the last harrowing.

PREPARATION OF THE SEED.

CLEANING AND GRADING THE SEED.

The yield of oats can be considerably increased by cleaning and grading the seed and by treating it to prevent smut.

Seed oats should be thoroughly cleaned and graded before sowing. The stand produced from heavy seed is better and more uniform than that from ungraded seed. The strong, vigorous plants produced from plump, heavy seed stand the winter better than the weak ones which grow from light shriveled grains; their growth is better throughout the season and the yield larger. Cleaning the seed not only removes the weak, light grains of oats but takes out many weed seeds. Most of the seeds of cheat or chess, one of the most troublesome weeds in oat fields, can be removed by thorough cleaning.

Seed oats are usually cleaned and graded with the fanning mill, but where this machine is not available and the quantity of seed sown is small, fairly effective work can be done by pouring the grain back and forth from one vessel to another in a brisk wind. If a considerable quantity of seed is to be cleaned, the gain from sowing cleaned seed will soon repay the cost of a fanning mill.

TREATMENT OF SEED FOR SMUT.

A considerable portion of the oat crop is lost each year from the attacks of the smut fungus. This loss is easily and cheaply prevented by treating the seed before sowing with a solution of 1 pound of formalin to 40 gallons of water.[a]

The grain should be placed on a clean floor or canvas and sprinkled with the solution. The pile should be shoveled over occasionally while applying the formalin, to make sure that all the grain is thoroughly moistened. It should then be covered with blankets or canvas and left for several hours, when it may be sown at once or spread out to dry. It will run through the drill much better if dried before sowing. Grain may also be treated by pouring it into a tub of the solution, stirring thoroughly, and spreading out to dry after it has remained in the solution twenty or thirty minutes. Sprinkling is just as effective, however, and is a cheaper and more rapid method. Care should be used not to put the treated grain into bins, sacks, or machinery where it is likely to come in contact with smut spores.

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[a] Farmers' Bulletin 250, entitled "The Prevention of Stinking Smut of Wheat and Loose Smut of Oats," gives complete directions for the use of the formalin treatment.

SOWING THE SEED.

The success of the winter-oat crop depends in a large measure on the time, the rate, and the manner of seeding. Early seeding with the grain drill or in open furrows, using 2 bushels of seed to the acre, is recommended.

TIME OF SEEDING.

Winter oats are less hardy than winter wheat or barley and for that reason should be sown earlier, so that the plants may become well rooted and make considerable top growth before cold weather. Oats are seldom attacked by insects in the fall, so that there is no necessity for delay in seeding, as with wheat where the Hessian fly is common. In the extreme South, seeding need not be done until November, but farther north September and October are the best months.

In Oklahoma, northern Arkansas, Kentucky, Tennessee, Maryland, and the higher portions of Virginia and North Carolina seeding should usually be completed by September 20. The Virginia station secured an average yield of 30.64 bushels to the acre in a four-year test from Culberson oats sown September 15, 28.06 bushels from those sown September 30, and 15.32 bushels from the seeding of October 15, while in three of the four years the plats sown October 30 were a total failure. At the Maryland station better yields were obtained from seeding September 1 than two or four weeks later.

In the lower portions of Tennessee, Virginia, and North Carolina, the mountain sections of South Carolina, Georgia, and Alabama, southern Arkansas, and in northern Mississippi and Texas, the seed should ordinarily be sown between September 20 and October 10. In northern Louisiana, central Texas, Mississippi, Alabama, and Georgia, and the lower portion of South Carolina seeding may be done almost any time during the month of October, while along the Gulf coast late October and early November seeding is usually satisfactory. Time-of-seeding tests have not been reported in recent years from any of the Southern States except Virginia. October seeding in Georgia and Alabama is advised, however, by the agricultural experiment stations in those States.

METHOD OF SEEDING.

The methods of seeding winter oats are (1) broadcast seeding; (2) drilling with the ordinary grain drill; and (3) drilling with a specially devised drill by what is known as the open-furrow method.

Broadcast Seeding.

Winter oats are sometimes sown broadcast, but this method is not to be recommended. When sown broadcast and harrowed in, much of the seed is left near the surface, even in well-prepared ground, so that many of the plants are shallow rooted and are killed by heaving or cold. A better method, where broadcast seeding is necessary, is to sow the seed on clean ground which has been disked, covering it about 3 inches deep with the turning plow. The ground should then be left rather rough, as the uneven surface furnishes some protection for the plants. More seed should be used in broadcast seeding than in drilling.

Drilling the Seed.

The use of the grain drill in sowing winter oats is strongly recommended. Drilling produces a more uniform stand and more even germination and growth than broadcast seeding. Drilling also requires less seed and the plants are less likely to winterkill. Drilling at least 3 inches deep on well-prepared land, leaving the drill furrows as open as possible, is advised. Drag chains should not be used on the drill, nor should the land be harrowed after drilling. This leaves the seed in the bottom of shallow furrows, which in a measure protect the young plants from winterkilling. Figure 8 shows a disk drill as it should be used in sowing winter oats.

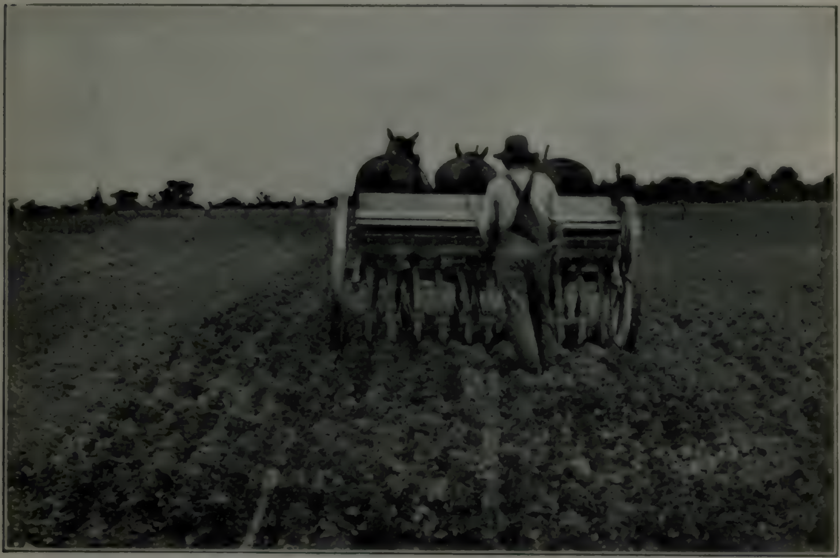

FIG. 8.—A disk drill with drag chains removed, as it should be used in sowing winter oats.

As the grains of varieties of the Red Rustproof type are likely to stick together, the drill should be watched closely to see that the seed is being evenly distributed. A drill with a good force feed will sow this variety quite satisfactorily.

The Open-Furrow Method of Seeding.

The Georgia experiment station a number of years ago devised what is known as the open-furrow method of seeding oats. By this method the seed is sown in drills from 16 to 24 inches apart, the ordinary single-row planter or a specially devised drill being used for the purpose. If desired, a drill with a fertilizer attachment may be used and the fertilizer distributed in the furrows with the seed. A combined grain and fertilizer drill, for sowing 4 rows 16 inches apart by the open-furrow method, is shown in figure 9.

The seed is sown in drills or furrows several inches deep, so that the roots and crowns of the plants are 2 or 3 inches below the surface. The rains and alternate freezing and thawing partially fill these furrows, but the plants are still left well below the surface. Running the drills across the usual direction of the winter winds is recommended by the Georgia station as an additional protection, as the slight wall of earth prevents the full force of the wind from striking the plants. Thus, if the coldest winter winds are ordinarily from the northwest, the drills should run northeast and southwest.

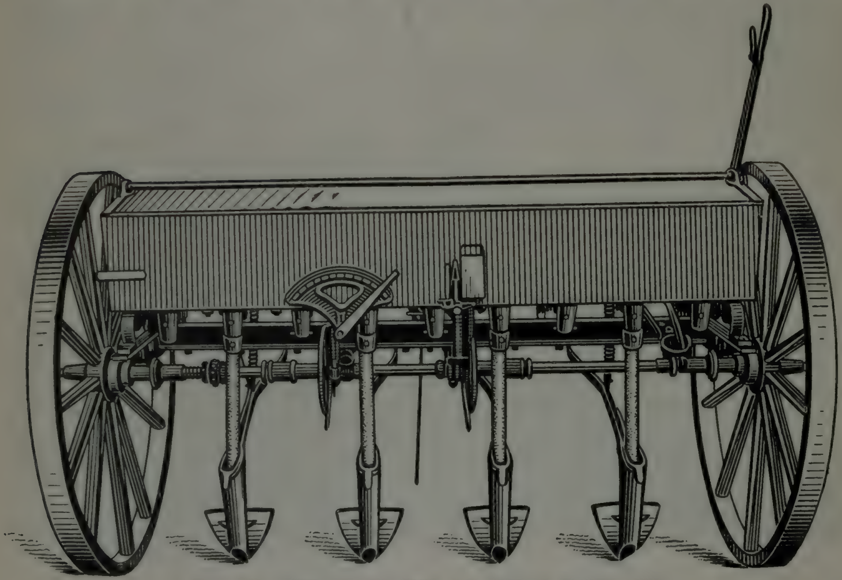

Fig. 9.—Open-furrow drill for sowing winter oats.

In a four-year test at the Alabama station the open-furrow method of seeding was compared with broadcast seeding. The average yield for the broadcast plats was 24.2 bushels to the acre, while the plats drilled in deep furrows yielded 27.4 bushels. Drilled plats in which the furrows were filled after seeding averaged 26.7 bushels. This station recommends the open-furrow method on well-drained land; on wet or very level land water may stand in the furrows long enough to injure the crop.

RATE OF SEEDING.

The rate of seeding usually recommended for Red Rustproof and similar varieties of oats when sown with the open-furrow drill is 2 bushels to the acre. When sown with the ordinary drill 2½ bushels is about the proper rate. Broadcast seeding requires still more seed, from 3 to 4 bushels being necessary. As the Winter Turf oat is somewhat hardier and stools more than the Red Restproof, it may be seeded at a lower rate, from 1½ to 2 bushels when drilled or 2½ bushels when sown broadcast. In the northern portion of the winter-oat area, where the danger from winterkilling is great, and farther south when late seeding is necessary, the rate of seeding should be somewhat increased.

From 2½ to 3 bushels of the Red Rustproof or Culberson and 2 to 2½ bushels of the Winter Turf are about the proper rates of seeding for the colder portions of the winter-oat belt. When the crop is to be used for pasture or hay somewhat heavier seeding is advisable than where it is grown for grain. When used as a nurse crop for grasses or clover, or when grown with crimson clover or vetch, less seed should be used than when oats are grown alone.

TREATMENT OF THE LAND AFTER SEEDING.

Top dressing with barnyard manure in the fall and the application of nitrate of soda in the spring have already been discussed as means of increasing the yield of fall-sown oats. Injury to the plants from heaving during the winter and early spring, with the consequent exposure of the roots to the sun and wind, may sometimes be prevented by rolling the land as soon as possible after the heaving takes place. Clay soils, the type on which heaving is most likely to occur, should not be rolled when wet, so that this method of reducing the damage can not always be used. Harrowing in the early spring will help to keep weeds in check and will also loosen the hard surface soil and prevent loss of moisture. When the open-furrow method of seeding is used the ridges between the rows should be leveled down in the spring with the harrow.

Winter oats, like other winter grains, are sometimes used as pasture for stock. Early seeding is particularly essential when the crop is to be pastured in the fall. Pasturing at this time always increases the danger from winterkilling, as it lessens the protection afforded by the leaves. Winter oats should not be pastured as closely as winter wheat or rye, as the oats are less hardy than the other grains. Pasturing in the spring delays maturity. As earliness is essential to the production of a good crop of oats the value of the pasture does not usually make up for the loss in yield of grain. Winter-grain fields should never be pastured when the ground is wet, as the trampling injures the physical condition of the soil. Harrowing in the spring to loosen soil which has been packed by pasturing is beneficial to the crop.

SPRING SEEDING OF WINTER OATS.

Even though all precautions are taken, the stand of winter oats may sometimes be destroyed by cold weather or the effects of alternate freezing and thawing. As a safeguard against total loss when this occurs, the Georgia station suggests that a small part of the land to be devoted to oats be left unseeded each fall. If the fall-sown oats survive the winter, this portion of the field is sown to Burt oats as early as possible in the spring. On the other hand, if the fall-sown oats winterkill, the large field is sown to Burt oats in the spring and the small one to the winter variety in order to get seed for sowing the following autumn. The Alabama station found that the hardiness and yield of Red Rustproof oats were not injured by sowing one year in the spring, so that this plan may be followed without danger of loss. The smaller portion of the field should be large enough to produce sufficient seed of the winter variety to sow the entire crop the following fall, if necessary. Enough seed of the Burt to sow the larger area and enough of the winter variety for the small one should be reserved each year until the danger of winterkilling is past.

WEEDS.

One of the most common weeds in winter-oat fields is cheat, or chess. The popular belief that oats turn to cheat is due to the rapid, vigorous growth of this weed and the manner in which it occupies the ground where grain has winterkilled. Occasional plants of cheat, which would hardly be noticed in a good stand of oats, grow so vigorously and stool so abundantly when given plenty of space by the winterkilling of the oats as to give the impression that the entire crop has turned to cheat. When a considerable proportion of the crop is cheat, the best plan is to cut the oats and cheat together for hay before the seeds mature. If the oats are entirely killed the cheat should be plowed under and the land used for a cultivated crop. Other winter weeds, such as chickweed, shepherd's-purse, and peppergrass, sometimes cause trouble, but these are not often serious pests and can usually be kept in check by harrowing. Weeds which do not start growth until spring do not often cause trouble, as the growth of the crop is rapid at that season. Rotation of crops, good cultivation, and thorough cleaning of seed grain are strongly recommended as means of keeping weeds under control.

HARVESTING THE CROP.

Oats are usually cut with a grain binder, but where the area is too small to justify the use of this machine, a mower or even a cradle may be used. If cut with the binder the grain should be allowed to stand until nearly ripe or until just after it passes out of the hard dough stage. The bundles or sheaves should be set up in round shocks of 10 or 12 bundles each, using 1 or 2 bundles for caps or covering with canvas shock covers. The bundles should be thoroughly dry when shocked and the shocks should be carefully built, so that the grain is exposed as little as possible to the weather. If it is necessary to cut the oats with a mower, they should not be as ripe as for binding, or there will be loss from shattering in handling. The oats usually grown in the South do not shatter readily, however. When cut with the mower the grain should be allowed to cure for a short time in the swath or windrow, and should then be placed in well-built cocks and, if possible, covered with canvas covers.

When the grain has cured in the shock, which will be in about ten days if the weather is good, it should be stacked or placed under cover. If a thrashing machine is available, it may be thrashed at once. In any case, it should be dry when stacked or stored, as it is likely to mold if at all damp. Grain which has been cut with the mower may be stacked as soon as cured, and may then be handled in the same manner as that which is bound. In either case, it may, with little loss, be fed to stock without thrashing, or it may be thrashed when thoroughly dry. If it is thrashed, the grower should see that all the grain is removed from the straw and that the separation of grain and chaff is complete. After thrashing, the grain should be stored in tight bins, where it is protected from the weather and from vermin. The straw should be run into the barn or carefully stacked, so that the loss from weathering will be slight.

If the crop is to be used for hay, it should be cut after the grain is developed but before the straw becomes tough and hard. If it is grown with vetch, crimson clover, or some other crop, the time at which it is cut will depend to some extent on the state of maturity of the crop with which it is grown. The hay should be cured in the windrow and cock, with as little exposure to rain as possible, and should be placed under cover or stacked as soon as it is cured. The curing of hay is sometimes difficult in the South, owing to frequent rains, and the best quality can be secured only by protecting the cocks from the weather by the use of canvas covers. If these are carefully stored when not in use, they will last for a number of years and will prove a good investment. Oats may be cut for soiling (feeding green) as soon as the heads begin to show, and cutting may continue until the crop is nearly ripe. If cut in the early stages, the stubble will produce a fairly heavy second crop.

YIELDS.

As previously stated, the oat yields of the Southern States are low, averaging from 15 to 25 bushels to the acre. It is safe to assume, however, that the yield of winter oats in these States is considerably higher than that of the combined fall-sown and spring-sown crop. The yield of winter oats at the Alabama station from 1897 to 1906 varied from 5.5 to 62.5 bushels to the acre, according to the variety and the season, with an average of about 30 bushels. The Georgia station reports yields as high as 65 bushels. In the black waxy belt in Texas the production of from 60 to 80 bushels to the acre is not uncommon in favorable years, while more than 100 bushels are sometimes produced.

IMPROVEMENT OF THE CROP.

Thorough cleaning and grading of the seed each year insures the grower against the running out of the strain, which is so generally believed to occur; in fact, there will be a gradual improvement in the yield and quality of the crop. Good home-grown seed is always better and safer than that of unknown origin which can be secured on the market. Little is to be gained, and there is considerable chance of loss when seed oats are brought from distant points, unless the seed is known to be pure or of selected strains. Otherwise it may contain troublesome weeds, be low in germination, or of a strain which is not winter hardy.

The improvement of oats through the selection of individual plants or heads and the testing of these selected strains is interesting and valuable work for those who have the time and patience to devote to it.[a] The best heads should be selected from strong, vigorous plants growing under normal conditions. Those which stand along the edges of the field or in open spaces should not be selected, as their vigorous growth is due to especially favorable conditions. The selected heads should be thrashed separately by hand, and the seed from each planted in a row by itself. Those which appear to be most promising should be selected the following season for further testing; the remainder should be discarded. The seed from each of the selected rows is thrashed and planted, the best rows being again selected at harvest time for further testing and increase the next year. Those which appear to be most promising should be increased as rapidly as possible. If all the seed is used, enough for large fields can be grown from a single head in a few years.

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[a] The method of testing these strains is described in detail in Circular 30, Bureau of Plant Industry, U. S. Dept. of Agriculture, entitled "Improvement of the Oat Crop."

INSECTS AND DISEASES.

The insect which is most likely to cause damage in growing oats in the South is the spring grain-aphis,[a] or "green bug." As this insect usually appears on small areas and in limited numbers at first, it can best be kept in check by plowing under the grain on these areas or destroying it by other means. Though the hulls protect oats to some extent from weevils and grain moths which attack the grain in the bin, these insects sometimes do considerable damage. The two most effective means of combating them are fumigation of the grain in tight bins with carbon bisulphid and with hydrocyanic-acid gas.[b]

Rust and smut are the two diseases which are most likely to affect the oat crop seriously. Conditions in the South are usually favorable to the development of rust, which needs damp, warm weather. The best preventive measures are the planting of rust-resistant varieties (the Red Rustproof type) and sowing only on well-drained land. Drilling in wide rows which admit the light and air, and the use of fertilizers rich in phosphoric acid and potash, thus inducing early maturity, also aid in keeping rust in check. Oat smut can be controlled by the use of the formalin treatment already mentioned.

FEEDING VALUE OF OATS.

The feeding value of oats largely depends on the proportion of kernel to hull, as the hull contains little digestible material and a large amount of crude fiber. A good sample of oats contains from 65 to 75 per cent of kernel. Well-matured samples of Red Rustproof and other winter oats grown in the South show as high a percentage of kernel and as high feeding value as good spring oats grown in the North. An average sample of oats contains about 89 per cent of dry matter, or practically the same as wheat, barley, and corn. One hundred pounds of oats, according to Henry,[c] contain 9.2 pounds of digestible protein, 47.3 pounds of digestible carbohydrates, and 4.2 pounds of digestible fat. This is more protein or flesh-forming food than is contained in 100 pounds of corn or barley, and nearly as much as in a similar quantity of wheat. Henry's figures are based largely on analyses of spring oats, but, as stated, analyses of winter oats show no definite differences in composition. Oats contain only about two-thirds as much digestible carbohydrates as wheat, barley, or corn, but this difference is in part made up by the fact that they contain more than twice as much fat as either barley or wheat. Corn contains slightly more fat than oats.

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[a] Circular 93, Bureau of Entomology, U. S. Dept. of Agriculture, describes the spring grain-aphis and gives methods for its control.

[b] Farmers' Bulletin 145 gives directions for fumigating grain with carbon bisulphid. Circular 112, Bureau of Entomology, furnishes directions for treatment with hydrocyanic-acid gas.

[c] Henry, W. A. Feeds and Feeding, 9th ed., p. 632.

The feeding value of oat straw is higher than that of the straw of any other small grain and is nearly as great as that of corn stover (fodder with the ears removed). As well-cured oat straw can usually be fed with less waste than corn stover, the actual feeding value of a ton of oat straw is probably equal to that of a ton of corn stover. One hundred pounds of oat straw contain 90.8 pounds of dry matter, while the digestible nutrients in 100 pounds of oat straw consist of 1.2 pounds of protein, 38.6 pounds of carbohydrates, and 0.8 pound of fat.[a]

Oat hay is higher in all the food constituents than timothy hay, which is frequently shipped into the South and sold at high prices. The feeding value of oat hay depends on the proportion of grain to straw. Mature plants of the Red Rustproof variety usually produce about as much grain as straw, while in the Winter Turf variety the weight of the straw is often double that of the grain. As the grain is not fully developed when the crop is cut for hay the proportion of grain to straw in oat hay is less than in the mature plants. Hay made from the Red Rustproof oat is higher in feeding value, ton for ton, than that from the Winter Turf, on account of the greater proportion of grain it contains. On account of the smaller yield, however, the hay from an acre of the Red Rustproof oats usually contains less feed than that from an acre of the Winter Turf.

FEEDING THE GRAIN TO STOCK.

The high value of oats for feeding to horses and mules is generally well understood. The market price of oats in the South is usually so high that this grain can not be fed with profit to any other class of animals. Even when fed to horses and mules the most economical results can be obtained by substituting corn for a part of the oat ration. Recent experiments show that a small quantity of cottonseed meal can be added to the ration with safety to make up for the deficiency in protein when corn is fed to work stock. If the ration for work stock is made up of equal parts of oats and corn its efficiency will not be decreased, but the cost will be materially lessened, unless corn is unusually high in price. Oats are particularly valuable for feeding to colts and to other young and growing stock. The value of this grain for feeding to young animals is due to its high proportion of ash, or bone-forming material, and of protein, or muscle-forming material.

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[a] Henry, op. cit., p. 633.

When oats are not too high in price they are a valuable grain for feeding to dairy cows, sheep, and poultry. As they are not fat-producing, they are not of value in fattening cattle, while their high proportion of crude fiber makes oats an inferior feed for hogs. Oats are usually fed whole to all kinds of stock, though for young animals or for older ones with poor teeth the grain should be crushed.

OAT STRAW.

Oat straw, as previously stated, is a better feed than the straw of any other small grain. It is a valuable roughage for feeding to all kinds of stock not at hard work, but contains too much waste material to make up the entire ration. When fed with cowpea or other hay which is high in feeding value it gives bulk to the ration and lessens its cost.

Oat straw is valuable in making and saving manure; when used as bedding it absorbs and holds a large part of the liquid manure. It also adds to the value of the manure, as the ammonia, phosphoric acid, and potash in a ton of oat straw at present prices would cost at least $3. The straw makes a good mulch for trees, small fruits, and vegetables, but should not be used for this purpose unless it is quite free from weed seeds.

OATS AS HAY AND PASTURE AND FOR OTHER PURPOSES.

Oats make excellent hay, which matures early enough in the season to allow the production of another crop on the land. The yield is heavy, from 1 to 3 tons to the acre, according to the fertility of the soil, and the quality is high. The hay is easily cured and is relished by all kinds of stock. The yield and feeding value may both be increased by growing vetch or some other leguminous crop with the oats.

Good pasture for stock of all kinds is produced by winter oats. As previously stated, however, pasturing the crop usually reduces the yield of grain. When the pasture provided by a winter-grain crop is an important item it is usually better to use wheat or rye, as either of these crops may be pastured quite closely and yet produce a satisfactory crop of grain. If desired, oats may be pastured closely in the spring, then plowed under and the land planted at once to some other crop. Vetch and oats together make good pasture, particularly for sheep and hogs.

As a soiling crop oats can not be used as early in the spring as rye, but the feed produced is of better quality and can be used for a longer period. The quantity of green feed produced by oats is large and the crop can be used over a considerable period. If cut early, a good second crop is produced. Cutting can be begun as soon as the plants begin to show heads and may be continued until the grain is nearly ripe. Green oats are relished by all kinds of stock and there is little waste in feeding. Vetch or crimson clover, grown with the oats, improves the quality of the green feed produced.

Oats are also used as a nurse crop and as a cover crop. The use of winter oats as a nurse crop is rather rare in the South, as grass or leguminous crops are not often sown for the production of permanent meadows. In general, these crops succeed better in the South when seeded without a nurse crop. Where a nurse crop is used, wheat and barley are to be preferred to oats, as they make less shade. As a winter cover crop, to prevent washing of the soil, the value of winter oats has already been stated.

SUMMARY.

Only a small portion of the area of the Southern States is devoted to the production of oats. The average production for the past ten years of 16 States was about 870,000,000 bushels, or 8.5 per cent of the crop of the United States. The average acre yield was 21.8 bushels and the average acre value $10.09.

Winter oats are a valuable crop for the South, as they form a soil cover during winter, which prevents washing, and produce considerable quantities of grain and forage for stock.

Winter oats are superior to spring oats in the South, as they mature earlier, provide a soil cover, produce larger yields, and allow more time for the preparation of the land for spring crops.

Two types of winter oats are commonly grown, the Red Rustproof and the Winter Turf. The Red Rustproof is rather less hardy than the Winter Turf, but yields more grain and matures earlier. The latter is recommended for the northern portions of the winter-oat belt and for use as a hay and pasture crop.

Winter oats can be grown in all the Southern States and as far north as Delaware, Maryland, Kentucky, and southern Missouri. The crop is not certain to survive the winter over a large portion of this area, however.

Any soil which will produce a good crop of cotton or corn will grow oats, but the best results are usually secured on one that holds moisture well. Nitrogen should be supplied by growing a leguminous

crop on the land, while potash and phosphoric acid should be provided according to the needs of the soil. Top dressing in the fall with barnyard manure and in the spring with a small quantity of nitrate of soda is recommended.

One of the best rotations for the cotton States includes corn and cowpeas, oats followed by cowpeas, and cotton in a three-year rotation. Outside the cotton belt wheat and a forage crop may take the place of cotton.

The land should be prepared by plowing, disking, and harrowing, so that a loose, mellow seed bed is produced.

The seed should be thoroughly cleaned and graded and only the largest and heaviest grains sown. It should be treated for smut with a solution of formalin.

Early seeding is advisable to secure strong growth of both root and top in the fall. When the seed is drilled the sowing of 2 to 3 bushels to the acre of the Red Rustproof or 1½ to 2 bushels of the Winter Turf is recommended. Heavier seeding is necessary when the seed is sown broadcast. Sowing with the ordinary grain drill or the specially devised open-furrow drill is to be preferred to broadcast seeding.

Winter grain that is injured by heaving may sometimes be saved by rolling as soon as possible after the injury occurs. Pasturing usually reduces the yield of grain. Fields which have been pastured may be benefited by harrowing.

A small portion of the field should be reserved each year for seeding to a spring variety. If the fall-sown crop winterkills, the large portion should be sown to the spring variety and the small one to the winter variety, in order to secure seed for sowing the following fall.

Rotation of crops, cleaning the seed, and harrowing are advised as methods of keeping down weeds.

Oats are usually cut with a grain binder or with a mower. They should be carefully shocked or cocked to prevent weathering. The grain should be thrashed when thoroughly dry and stored in tight bins. If oats are grown for hay, the crop should be cut before the straw becomes hard, and cured with as little exposure to the weather as possible.

Yields of from 30 to 60 bushels to the acre are not uncommon on good land, while more than 100 bushels to the acre have been produced.

Thorough cleaning of the seed grain each year will improve the yield and quality of the crop. It may be further increased by the selection and testing of individual strains.

The spring grain-aphis is the insect most likely to damage the growing crop; grain weevils and moths attack the stored grain. Rust and smut are the most serious diseases.

Oats are about equal to barley and wheat in feeding value. Corn is a better fattening feed. Oat straw is better than the straw from any other grain. Oat hay is equal to the best timothy hay.

Oats can be fed to all kinds of stock except hogs. They are usually used for feeding to horses and mules, as they are too high in price to feed to other animals. The straw may be used as a feed, as bedding, and as a mulch for fruit crops. Oats may be used for hay or pasture, or as a soiling crop. They may also be used as a nurse crop or as a cover crop.

[A list giving the titles of all Farmers' Bulletins available for distribution will be sent free upon application to a Member of Congress or the Secretary of Agriculture.]

Issued April 1, 1911.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 437.

A SYSTEM OF TENANT FARMING AND ITS RESULTS.

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WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., February 6, 1911.

Sir: I have the honor to transmit herewith and to recommend for publication as a Farmers' Bulletin a manuscript entitled "A System of Tenant Farming and Its Results," prepared by Mr. J. W. Froley, Assistant Agriculturist, and Mr. C. Beaman Smith, Agriculturist, under the direction of the Agriculturist in Charge of the Office of Farm Management of this Bureau.

Respectfully,

Wm. A. Taylor,
Acting Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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A SYSTEM OF TENANT FARMING AND ITS RESULTS.

INTRODUCTION.

It is a well-managed farm that pays the owner fair wages and 5 per cent interest on the investment while keeping up the fertility of the soil. Some farmers make considerably more than this. A much larger number make less.

By basing calculations on the yields from a few of the best fields, or on the returns from especially favorable seasons, or on a few of the best live stock, it is possible to figure out large profits in farming. Likewise, by assuming better business management for the farm, comfortable theoretical profits are worked out. Nevertheless, in actual practice and for many reasons not forseen at the outset the average profits in farming, aside from the rise in value of the land itself, are not large, but on the other hand extremely modest.

The most profitable farms are usually those managed by the owner living on them. Should the owner tire of farming and move away or buy or inherit a farm and attempt to run it at a distance by hired labor, he generally finds the results distinctly unsatisfactory and soon decides to sell or rent the farm.

There are many good reasons, however, for not selling the farm. Land is usually a very safe form of investment. It neither burns up nor absconds. It may appreciate enough in value as the country becomes settled to pay interest on the investment, even if no crops are grown. In any event, it will, if paid for, always furnish a home and an opportunity of earning a living. Therefore men part with farm lands reluctantly.

Rather than sell the farm or attempt to run it at long range with hired help, some method of renting it is tried. The owner comes to believe that results will be better and that he will get larger returns if he puts the farm in the hands of a tenant who has a more direct interest in its output than a hired man. In this direction also disappointments are frequent.

Disappointments in tenant farming arise because of (1) the too frequent lack of an equitable adjustment of the returns of the farm between owner and tenant; (2) the lack of well-laid plans for keeping up the yields and the productiveness of the farm through the years; and (3) short-term leases, which keep the tenant in an unsettled frame of mind as to the permanency of his tenure and lead him to endeavor to get as much out of the land each year as possible, with little or no attempt at soil improvement or wise farm management, thus contributing to the deterioration of the farm.

WHY TENANT FARMS DETERIORATE.

In tenant farming there are two main reasons why farms usually deteriorate: (1) The owner desires as large a share as possible of the profits of the farm and frequently hesitates to put any large portion of the profits back on the farm in the way of permanent improvements or in keeping up the place, and (2) the tenant regards the farm primarily as a means of acquiring enough money to buy one of his own, and conducts the rented farm along the line of the greatest immediate financial returns to himself. It is the farm that suffers in each case. The generally decreasing returns soon bring discontent both to owner and tenant, and frequent changes of tenant follow.

A proper and equitable adjustment between owner and tenant is not easily made, but is the end to be sought. It would insure more permanent tenancy. It would relieve the owner of the duties of management and the tenant of the burden of acquiring large capital before he goes into business for himself.

ADVANTAGES AND DISADVANTAGES OF TENANT FARMING.

Speaking generally, tenant farming is not a type to be encouraged in America. Small farms tilled by their owners are regarded as the ideal, because such farms tend to build up a conservative, home-loving people. Nevertheless, tenant farming is here. It is a fact. There is, besides, a place for tenant farming in American agriculture. Cheap, fertile farms are largely a matter of the past. The homesteads of the West are practically gone. If a young man desires to go into farming in these days, he requires considerable capital. It takes a long time, working out by the day or month, to acquire that capital, and good land is expensive. If he wishes to buy a farm, it usually takes all the money and credit at his command to buy the land alone.

The acquisition of the land is only the beginning of the struggle. Investigations have shown that in farming only about half the capital required is invested in the land. The remainder is invested in buildings, fences, farm machinery, tools, and live stock, sufficient cash being kept on hand for running expenses. Many a man buying a farm will put all his money into the land and then struggle the remainder of his life with insufficient working capital, trying to meet expenses and make the farm earn its equipment. A mere existence rather than a living is too often the result.

Should the same man let some one else furnish the farm and put his own money into the working and proper handling of it he would require much less capital. He would be relieved of a large burden of debt, and with adequate equipment and cash on hand the farm would be run far more efficiently and, generally, to his greater profit.

There is a place, then, in our present agricultural system for tenant farming. A man who has acquired some money, as a laborer or otherwise, who desires to be independent but who has not sufficient money or credit to buy and efficiently equip a complete farm, may let some one else furnish the farm while he furnishes the labor and part or all of the equipment and other working capital. Whether the results of such an arrangement are mutually satisfactory depends upon several factors, which may be profitably considered more in detail.

FUNDAMENTAL PRINCIPLES OF TENANT FARMING.

It is difficult enough to make a farm pay even when the owner runs it himself and receives all the profits. As commonly handled, it is increasingly difficult to make the farm pay when run by a tenant who has little or no financial interest in it and when the profits are divided. The owner may make the farm pay through long hours of hard work, by saving, by careful regard for his stock, and by the distribution of crops and manure so as to keep up the productiveness of all the farm. He seeks to keep up the place so that the farm will present a good appearance and increase in value. With a tenant who has only an immediate interest in the farm, some more definite plan must be adopted if the farm is to pay both owner and tenant.

Some of the guiding principles essential to success in tenant farming follow:

1. A cropping and fertilizing system which will return satisfactory yields of each crop yearly and still maintain permanently the productiveness of the farm throughout future years must be provided. The owner should make the plan.

2. Terms of agreement as to rental must be fair to both owner and tenant. If advantage is taken by either owner or tenant of a lack of knowledge in the other of what is a fair adjustment of the returns from the farm, the results are bound to be unsatisfactory and the relationship brief.

3. The terms of the lease should be such as to lead to permanent tenancy. A tenant can not and will not do his best by the farm if

he is to remain on it for only a short period. As a tenant he must be made to feel that his position is permanent just as long as he does the square thing by the farm and the owner.

While it is easy to say that tenant farming should be wisely planned with reference to large yields of paying crops and permanent maintenance of the fertility of the soil, it is not so easy to make that plan. American farmers have not long been thinking about permanently productive farms. In the past it has been simpler to abandon the old fields when they failed to produce satisfactory crops and clear new land, or perhaps to move farther West and buy a new farm. The time has come when it will be necessary to keep productive the fields now farmed. Cheap new lands are practically a thing of the past, and more and more must attention be given to kinds of farming that are permanent rather than exploitive, that will yield as well for the son as for the father.

AN EXAMPLE OF TENANT FARMING.

THE ESTATE AND THE SYSTEM.

In the older sections of the eastern United States the necessity for considering permanent types of farming has long been felt and much effort has been made to meet the need. A very good example of success in solving this problem along general farming lines is that of a large estate in eastern Maryland. This estate is the more interesting because it represents a system embracing 56 tenant farms under one ownership that has been in successful operation for more than 30 years. During this period yields of wheat and corn, which are the principal crops grown, have been maintained and in some cases increased. A large number of tenants have been on the estate for more than 20 years; several have been there for more than 30 years, and their sons have succeeded them.

These facts show clearly that the relationship between owner and tenant has been satisfactory. This is further brought out from the standpoint of the tenant by the fact that many tenants have made enough money by farming on the estate to buy farms of their own. In several instances, however, they are so well satisfied that they continue as tenants and rent their own farms to some one else.

On the other hand, the estate itself is fairly well satisfied. It has been able to keep up the productiveness of the different farms until many of them yield better than when bought. Attractive dwellings and substantial barns have been maintained on every farm, and all the fields are well fenced with board, hedge, or wire. Many fields have been enlarged by clearing waste places and made more productive by underdraining with tile. Every farm is clean, neat, and attractive in appearance.

The returns from the farm have paid for all these improvements, have paid all taxes, and are now bringing in to the estate more than 5 per cent interest on the total investment. Some of the farms have nearly trebled in value in the last 30 years. These returns to both tenant and owner are unusual. It is seldom that so large an estate is handled so satisfactorily, and a closer study of the system followed may prove profitable.

In detail, the estate consists of 15,630 acres, or about 24 square miles of land, subdivided into 56 farms varying in size from 98 to more than 1,000 acres, an average of about 279 acres per farm. These farms are scattered over a radius of about 12 miles from the central office. Considerable areas of waste land are found on some of them, so that on the average only about 72 per cent of the land is in actual cultivation. The price of cultivated land away from the influence of towns varies from $10 to $65 per acre, and these farms will probably show a like variation in value. The soil of most of the farms varies from a sandy loam to a clay loam, is comparatively free from stones, and is generally well adapted to wheat culture. The land is sufficiently level for the operation of labor-saving machinery.

One of the interesting facts relative to these farms and their organization into a profitable system of farming is that they were accumulated one at a time and organized by a merchant who had no special knowledge of agriculture, yet he formulated and put into practice over 30 years ago a system which has maintained yields and given satisfactory profits to both owner and tenants up to the present time. The latter is regarded as the most important fact in this bulletin.

At the time of the owner's death, 13 years ago, the system of farming which he put in operation had become so well established that with practically no change since then the yields of the farms have been maintained, a considerable indebtedness has been paid, the buildings and fences have been kept in a good state of repair, and a net income from the farms averaging a little more than 5 per cent has been paid to the estate.

THE CROPPING SYSTEM FOLLOWED.

The four-field system.—One of the fundamental reasons for the success attained on these farms is found in the cropping systems adopted. At the outset there were two of these systems, a four-field system and a five-field system.

In the four-field system all the cultivated land is divided as nearly as may be into four fields of equal size and a rotation followed of (1) corn, (2) wheat, (3) clover and grass, and (4) wheat. The second crop of wheat in the rotation is sown to clover, which is plowed down the following spring for corn. The fifth year corn follows wheat and the rotation is repeated. This system gives three-fourths of the farm to grain each year (half wheat and a fourth corn), while the remaining fourth is in clover and grass for hay or pasture. Oats are sown in the spring in the strips occupied by the corn shocks the preceding fall.

In this system the wheat is fertilized with a commercial fertilizer of high-grade materials, analyzing about 2 per cent of nitrogen, 8 or 9 per cent of phosphoric acid, and 2 per cent of potash, at the rate of 300 pounds to the acre. The barnyard manure made on the place is put on the corn crop. While this system has apparently maintained the productiveness of the soil, it has proved not nearly so popular with tenants as the five-field system. Many of the tenants who at first adopted the four-field have changed to the five-field system, so that at present there are scarcely half a dozen tenants in the whole estate who are following the four-field system.

The detailed farm practice in the four-field system is about as follows: The corn is cut up and the stover fed to sheep, cattle, and horses. The corn stubble is plowed and the field seeded to wheat and timothy in the fall and clover in the spring. This seeding of grass and clover stands over a year and is pastured, and possibly some of it is fenced off temporarily and cut for hay. The sod is then plowed for fall seeding in wheat, which is again seeded with timothy, followed by an application of clover seed in the spring.

This seeding of timothy and clover is used for pasture after the wheat is taken off until the following spring, when it is plowed again for corn, thus completing the rotation. All cornstalks and all wheat straw are run through the "pound," or barnyard, as fast as they can be utilized by the stock and the manure is put on the land for corn.

The five-field system.—The five-field cropping system is very popular with tenants and is well worth studying in detail. Fifty of the farms on the estate are following this system. The rotation in the five-field system is as follows: (1) Corn, (2) wheat seeded to clover, (3) clover for hay or pasture, (4) wheat, and (5) clover for hay or pasture. This pasture is again followed by corn and the rotation repeated. As in the four-field system, 300 pounds of fertilizer, analyzing 2 per cent of nitrogen, 8 or 9 per cent of phosphoric acid, and 2 per cent of potash, are used per acre on the wheat crop, and the barnyard manure is put on the clover sod and plowed under for corn. In the handling of the corn crop the stalks are cut and shocked in the field in long, compact rows in time for wheat seeding. The following spring the land occupied by the corn shocks, about one-twelfth of the total area of the field, is plowed and sown to oats and seeded down.

It will be noted that the five-field system differs from the four-field system in having an additional field of clover for either hay or pasture. This is one of the reasons why the five-field system is so popular with tenants, since it gives them more hay and pasture for their stock. While the total acreage of grain grown on the farm under the five-field system is a little less than it would be under the four-field system on a farm of like size, the estate believes that this extra clover crop sufficiently increases the yield on the smaller acreage planted to more than counterbalance any additional yield that might be secured with the larger grain acreage under the four-field system.

Special attention is called to the fact that in this system clover is sown with each wheat crop and that it remains but one year for either hay or pasture before being plowed under. In this way the maximum benefit of the clover crop as a nitrogen fertilizer for the soil is obtained.

The usual way of running a five-year rotation in many sections of the country is as follows: (1) Corn; (2) oats or wheat; (3) wheat; (4) hay; and (5) hay or pasture. In this system clover is sown but once in the rotation, and the second year there is usually but little left for fertilizing purposes.

TERMS OF RENTAL.

The system of rental which has proved so satisfactory to both tenant and owner, and which is followed on all the farms, is about as follows:

The agreement is drawn up for one year. If the contract proves mutually satisfactory it is continued in force during succeeding years without further attention. The owner furnishes the farm and buildings; furnishes paint for painting and lime for whitewashing buildings and fences; pays for all permanent improvements, such as the clearing of new lands or the tile draining of old lands; furnishes material for fencing; furnishes half of the fertilizer and half the seed wheat, seed oats, and seed corn, and pays the taxes on the real estate.

The tenant furnishes all tools and labor for working the place and all stock kept on the place. He also furnishes half of the fertilizer and half of the seed wheat, seed corn, and seed oats; furnishes all the clover and grass seed used, which by the terms of agreement is 8 pounds of pure clover seed per acre (though 1 to 2 quarts of timothy seed may be added); hauls material and builds fences free of expense to the estate, and applies the whitewash and paint furnished by the estate.

While the owner supplies all the buildings necessary for a general farm, he does not provide buildings which would be of use primarily for the tenant. Thus, if the tenant wanted to engage especially in dairying, the owner would derive no direct financial benefit from the industry and hence the tenant would have to put up, out of his own resources, such extra buildings as he might need.

In the division of returns the owner gets half of all the wheat, oats, and corn grown on the place, delivered free by the tenant at the elevator or nearest market. The tenant gets the remaining half of the oats, wheat, and corn, and in addition he has all of the hay and pasture, all the cornstalks, and all the straw for his stock. In case, however, any hay, straw, or stover is sold off the place the owner gets half the proceeds. In addition to this, the tenant is permitted to pasture a small flock of sheep on the wheat fields when the ground is frozen, from December to the last of March. This is of no advantage to the owner, but is of distinct advantage to the tenant.

It is a wise landowner who looks beyond a particular year to the future welfare and productiveness of the farm and makes terms with the tenant which tend to return to the soil each year a reasonable proportion of the plant food and humus removed and at the same time allows the tenant as large a measure of independence as possible. The simple provision requiring the tenant to pay the landlord half of all the money received for roughage sold off the farm, but requiring nothing if the roughage is fed to stock or left on the place, leaves the matter open to the discretion of the tenant, but inevitably tends, nevertheless, to the maintenance of a large number of stock on the place and the consequent production of a large supply of manure for the continued renewal of the productiveness of the soil.

It is now seen why the five-field system is a little more in favor with the tenant than the four-field system, since it gives him more pasture and hay, all of which he may have for feeding to stock. In this the tenant gets both the food value and the manurial value of the forage grown, while the owner gets only half of the increased grain yields obtained as a result of applying the manure produced by feeding this roughage on the place.

LIVE-STOCK MANAGEMENT.

In a system of farming such as is practiced on these farms, where the tenants are generally free to follow their own course in all matters except as to the cropping system, there is bound to be a wide variation in the management of live stock. Some of the tenants are inclined toward dairying, others toward the keeping of beef cattle, some toward the maintenance of as much stock as possible, even to the extent of purchasing considerable feed, while others keep as little stock as they think will economically consume the roughage raised.

On one of the farms, consisting of about 275 acres, which seemed to be typical of the average, there were kept about 9 head of work stock, 12 milk cows and their calves, 50 sheep, and 100 hens. While it is generally conceded that hogs would be a good paying investment if they could be kept free from cholera, very few were found on any of these farms, owing to the prevalence of this disease in that section of the country. Scarcely enough hogs are raised to supply the farm with meat.

The work horses and mules are kept up and fed practically the year round. They are fed principally corn, corn stover, and hay. The cows are allowed to run on clover pasture from about May 1 to October 1 and are not fed unless pasture becomes very short in August and September, in which case they may be fed green fodder. From October 1 to December 15 they run on pasture, but are fed fodder and corn, and from December 15 to May 1 they are kept in the barn and barnyard and fed corn stover, wheat straw, corn, and possibly some ground grain other than corn.

The grade sheep are pastured on the green, growing wheat in suitable weather from December to March, when they are turned into the clover field to stay until October 1 or November 1, after which date they are kept in the barn and barnyard and fed principally straw, stover, and corn. The ewes are bred to lamb in January and February. The lambs run with the ewes until some time in May or June, when they are sold at weights of 40 to 50 pounds each at a price averaging about $5.50.

Under the system of management described, this stock consumes about all the grain and forage of the farm available for the use of the tenant. A greater number of stock would make the purchase of feed necessary and a smaller number would leave a surplus of forage to be sold.

RETURNS TO TENANT AND OWNER.

The tenants on the farms of this estate are apparently as prosperous as the average farmer of the country who owns his farm. They live in commodious, substantial, and well-furnished houses, with well-kept and neat-appearing surroundings. They give their children up-to-date educational advantages. They apparently have plenty of leisure and carry on their farm work largely by means of hired labor.. As an illustration of their prosperity, one of them on a farm with 250 acres in cultivation, employing 3 men 10 months in the year and keeping 10 work horses, stated that during the last

11 years as a tenant he had out of his profits bought and paid for a farm costing $7,200 and had laid up about $600 besides. Meantime he has lived well, is educating his children in the city schools, and has done considerable traveling over the country. Another tenant on a farm of about the same size stated that his income from the sales of stock he was able to keep, by means of his pasture and roughage, was sufficient to pay the running expenses of the farm.

Relative to the owner's income per acre, it may be calculated that an acre of land in the five years of the rotation will return to him as his share 16½ bushels of wheat, 17½ bushels of corn, and 3 bushels of oats. Valuing the corn at 50 cents a bushel, wheat at $1, and oats at 40 cents, the total income to the owner from 1 acre of land in the five-year rotation is $26.45.

The total expense of the owner on 1 acre of land for the five years of the rotation is about as follows:

Owner's expense per acre for a five-year rotation.

600 pounds of fertilizer on 2 wheat crops (owner's half)	$3.00
Taxes at 1 per cent on land valued at $50 per acre (five years)	2.50
Seed wheat, 3 bushels at $1 (owner's half)	1.50
Seed corn, one-fourth bushel at $1 (owner's half)	.13
Seed oats, one-half bushel at 50 cents (owner's half)	.12
Incidentals for repairs, painting, whitewashing, etc	.50
Total expense on 1 acre for five years	7.75

Deducting the total expense, $7.75, from the total income, $26.45, leaves $18.70 as the net income to the owner from 1 acre of cultivated land for one round of the rotation of five years.

The income for 1 acre of cultivated land therefore for one year would be a fifth of $18.70, or $3.74. However, only about 72 per cent of each farm is in cultivation. The income per acre for the whole farm will therefore average 72 per cent of $3.74, or $2.69 per acre. With land worth $50 an acre this would give an average yearly income equivalent to about 5.4 per cent on the investment.

In addition to these current receipts of 5.4 per cent per annum on the present value of the farms of the estate, it is believed that at least an additional 3 or 4 per cent per annum on the original investment has accrued to the estate by virtue of the increased value of land, thus bringing the total income of the landowners up to approximately 8 or 9 per cent per annum.

YIELDS OF CORN AND WHEAT ON THE ESTATE.

That the yields of both corn and wheat have been practically maintained and the productiveness of the farms kept up under this system of rotation and fertilizing may be seen from the following tables, in which the yields from 21 of the farms for which data were available, covering a period of 20 years, are recorded.

TABLE I.—*Yields of corn per acre on the estate for 20 years.*

Number of farm.	Area cultivated.	Total yield of corn by 5-year periods.			
		1890-1894.	1895-1899.	1900-1904.	1905-1909.
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
1	245	7,005	8,290	6,585	6,235
2	425	13,630	13,600	11,680	11,305
3	360	17,800	14,905	13,560	13,975
4	286	8,110	10,410	10,055	11,885
5	195	5,970	8,255	7,355	8,230
6	272	9,635	12,415	8,795	11,530
7	175	6,010	5,680	4,805	5,575
8	205	5,105	11,190	8,450	7,525
9	150	4,055	5,145	4,440	4,635
10	250	[1] 5,625	6,450	5,600	5,925
11	229	[1] 5,625	10,280	6,555	6,895
12	250	8,435	9,615	8,055	8,660
13	555	17,735	18,570	16,655	18,000
14	220	7,055	10,490	7,840	8,375
15	175	6,530	8,305	6,405	7,415
16	434	22,100	22,100	19,885	18,380
17	291	12,275	13,455	13,340	12,210
18	250	8,185	10,640	7,145	6,815
19	307	10,080	10,865	8,845	7,675
20	195	3,895	5,610	4,945	5,045
21	190	4,605	5,000	4,450	4,415
Total	5,659	189,465	221,360	186,445	190,690
Average annual yield per acre		33.5	39.0	32.9	33.7

[1] Estimated from yields given for three years in the 5-year period.

In the following discussion it will be assumed that the average of the 21 farms represents the average of the 56 farms of the estate. The table shows averages of 33½ bushels of corn per acre for the first five-year period, 1890 to 1894, 33$\frac{7}{10}$ bushels for the last five-year period, 1905 to 1909, and about 35 bushels for the whole 20 years. These yields are not large, but they were obtained on farms where the area under cultivation was about 270 acres per farm. It is comparatively easy to get large yields on a few acres, but more difficult as the farm increases in size. While the general average, 35 bushels, seems very modest, it is greater than the average of the State of Maryland for the past 20 years by 7 bushels, greater than the average for the whole United States for the past 10 years by 9 bushels, and it is also better than the average corn yields of the State of Iowa for the past 20 years, and Iowa is one of the best corn States of the Union, with a large area of almost virgin soil, while many of these Maryland soils have been farmed for more than 150 years. The table further shows that the yields of corn on these farms to-day are practically as good, after 20 years of cropping, as in 1890.

The yields of wheat on the same farms, in five-year periods, are shown in the following table:

TABLE II.—*Yields of wheat per acre on the estate for 20 years.*[1]

Number of farm.	Area cultivated.	Total yield of wheat by 5-year periods.			
		1890–1894.	1895–1899.	1900–1904.	1905–1909.
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
1	245	8,348	7,316	8,109	7,337
2	425	13,918	17,061	13,055	12,623
3	360	16,774	14,492	13,010	11,250
4	286	8,074	8,658	8,333	10,315
5	195	6,500	7,001	7,368	7,119
6	272	9,415	10,301	10,800	9,790
7	175	5,420	5,406	4,776	4,872
8	205	7,048	6,596	6,578	6,033
9	150	5,911	5,774	5,126	4,911
10	250	[2] 7,833	7,800	7,600	7,360
11	229	5,565	8,818	8,162	7,793
12	250	7,585	9,831	7,960	8,550
13	555	14,878	16,001	17,440	17,014
14	220	7,501	8,158	7,810	7,777
15	175	6,605	6,518	7,800	5,625
16	434	18,659	19,175	18,387	17,385
17	291	12,567	14,270	12,494	11,433
18	250	9,077	8,036	8,878	8,287
19	307	10,740	12,616	10,315	9,161
20	195	5,397	6,079	5,626	5,781
21	190	3,455	5,077	4,660	5,312
Total	5,659	191,270	204,984	194,287	186,437
Average annual yield per acre[3]		16.9	18.1	17.2	16.5

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[1] About one twenty-fourth of the wheat fields was in oats. Had all the land been in wheat the yield would have been increased about three-fourths bushel per acre.

[2] Estimated from yield given for three years in the 5-year period.

[3] Two crops of wheat were raised in each 5-year period.

Table II shows an average yield of $16\frac{9}{10}$ bushels of wheat for the first five-year period, 1890 to 1894, and of $16\frac{1}{2}$ bushels for the last five-year period, 1905 to 1909, which results are practically identical. The two years, 1908 and 1909, were both very poor years for wheat on the estate, the yields being about 30 per cent less than normal. Thus, the average yield for the first three years of the last five-year period is $18\frac{1}{2}$, while the average yield for the last two years is but $13\frac{1}{2}$ bushels. Had the last two years been normal years, the average for this whole period would have been as good as the best of the five-year periods under discussion.

However, there is a suggestion in the decreasing returns of the past three five-year periods as shown in the table, viz, $18\frac{1}{10}$, $17\frac{1}{5}$, and $16\frac{1}{2}$ bushels, respectively, which may indicate that possibly the yields are actually decreasing and that the system of farming followed needs to be modified to meet this condition. This point will be considered again in the discussion of the fertilizer constituents removed in this system of farming.

The average yield of wheat on the estate for the past 20 years, $17\frac{1}{5}$ bushels per acre, is found to be larger than the average yield of wheat in Kansas for the same period, 2½ bushels greater than the average yield in Maryland, and 3 bushels greater than the average yield in the United States for the past 10 years.

While the above yields of corn and wheat are not fancy nor in any sense to be considered as models, they point out the fact that a good system well followed will maintain the fertility of the soil even in tenant farming.

The foregoing 21 farms were not selected from among either the best or the poorest of the 56 farms of the estate. The originator of the estate died in 1897 and a large number of the farms were bought in the later years of his life. The 21 farms where yields are given are the only ones for which records are available for 20 years or more, and, while the average yields for these farms seem to be very modest, yet they are greater than the averages secured in some of the best wheat and corn States.

RELATION OF THE FARMING SYSTEM TO FERTILITY.

Observing the tables presented showing yields of wheat and corn it will be seen that the land produces almost the same as it did 20 years ago. It will be interesting, therefore, to examine the situation as to the relative quantities of plant food taken from the land by the removal of crops and returned to the land by the application of commercial fertilizers and the return of manures.

The following table shows the yield of crops and fertilizer constituents in part required to produce them:

TABLE III.—*Average yield on 1 acre of each crop in the rotation, with the quantity of fertilizer constituents removed.*

Crop.	Average yield per acre.	Total fertilizer constituents removed.		
		Nitrogen.	Phosphoric acid.	Potash.
		Pounds.	*Pounds.*	*Pounds.*
Corn	Grain, 35 bushels	33	12	7
	Stover, 1½ tons	25	16	29
Wheat	Grain, 17 bushels	19	5	8
	Straw, 1 ton	11	2	6
Clover	1½ tons	60	17	55
Wheat	Grain, 17 bushels	19	5	8
	Straw, 1 ton	11	2	6
Clover	1½ tons	60	17	55
Total plant food utilized on 1 acre in the rotation		238	76	174

The table shows that in one round of the rotation the fertilizer constituents required to produce the crops grown on an acre are about 238 pounds of nitrogen, 76 pounds of phosphoric acid, and 174 pounds of potash. If all the crops were sold off the farm this would indicate in a measure the rapidity with which the farm was being depleted of its principal plant foods, with the exception of nitrogen; but in the system of farming followed all of the hay, wheat straw, clover, and about one-fourth of the corn is left or fed on the place.

All the wheat grown and about three-fourths of the corn are sold off the place. The fertilizer constituents left on an acre in a five-year rotation are therefore about as shown in the following table:

Table IV.—*Approximate quantity of fertilizing constituents left on 1 acre in a 5-year rotation.*

Rotation.	Returned to the soil per acre.	Total fertilizer constituents contained.		
		Nitrogen.	Phosphoric acid.	Potash.
		Pounds.	*Pounds.*	*Pounds.*
Corn	Stover, 1½ tons	25	16	29
	Grain, 9 bushels	8	3	2
Wheat	Straw, 1 ton	11	2	6
Clover hay	1½ tons	60	17	55
Wheat	Straw, 1 ton	11	2	6
Clover hay	1½ tons	60	17	55
Total		175	57	153

A large part of the crops shown in the above table is fed to stock or used for bedding in stables, and in this way finds its way, through the manure that is produced, back to the fields. In this process, however, the stock take toll of each substance for the building up and maintenance of their own bodies. Besides, nearly half of the fertilizing value of the manure excreted by animals is found in the liquid portion, much of which, under the system of housing followed on this estate, is made and lost in the barnyard. In addition to this there is considerable loss of manure from weathering. It is probably safe to assume that at the most not over three-fifths of the fertilizing constituents of these crops, as shown in Table IV, viz, 105 pounds of nitrogen, 34 pounds of phosphoric acid, and 92 pounds of potash, will be returned to the soil. In addition to the return of these quantities of fertilizing constituents to the soil, it will be remembered that in the rotation each of the wheat crops receives 300 pounds of a 2-8-2 fertilizer. The quantity thus returned to the fields in manure and in the fertilizer applied is shown in the following table:

TABLE V.—*Fertilizing constituents returned to fields in a 5-year rotation.*

Source.	Fertilizer constituents contained.		
	Nitrogen.	Phosphoric acid.	Potash.
	Pounds.	*Pounds.*	*Pounds.*
Barnyard manure, stalks, straw, etc	105	34	92
600 pounds of fertilizer	12	48	12
Total returned to fields	117	82	104
Total removed from fields, as shown in Table III	238	76	174
Quantity removed as compared with that applied	−121	+ 6	−70

The figures in Table V show that more nitrogen and potash are being removed from the soil than are apparently applied, while on the other hand more phosphoric acid is applied than is removed, and the soil, consequently, is growing richer in this element.

Investigations have shown that it is probably safe to assume that the two clover crops which are grown in the rotation and in large part pastured on the place will not only supply themselves with nitrogen, but will enrich the soil with this element sufficiently to supply the 121 pounds of nitrogen apparently taken from the farm and not replaced. The potash supply is regularly decreasing, but as much of the soil is a rather heavy loam and naturally well supplied with potash this comparatively slow decrease of 14 pounds to the acre per year on this character of soil probably need not be considered from the standpoint of the application of fertilizers for a number of years, except on the more sandy soils.

Summarizing briefly, then, with reference to the fertility of the farm, it is seen that the phosphorus of the soil is being maintained, that the humus and nitrogen content is probably being maintained, that the potash is being slowly decreased, but that there is probably a sufficient surplus of the latter element in all the heavier soils to supply the crop demands for years to come.

THE VALUE OF SYSTEM.

The result obtained on the estate under discussion strongly emphasizes the value of a proper system in farming. Without system the farm as a whole quite uniformly deteriorates. The comparatively slow decrease in the productiveness of many farms, accompanied frequently by variations in seasons which may result in increased or decreased yield independent of decrease of soil fertility, often blinds farmers to the fact that their farms are gradually growing less productive. Decreased productiveness is an inevitable result, however, on a large number of American farms as now conducted.

This decrease in productiveness on many American farms is due in a large measure to the fact that these farms are not properly managed. The owner frequently fails to keep records and does not know whether or not his system of farming is maintaining the yields of former periods. This he should know if he is to run his farm intelligently. He should know at the outset that his system adequately provides for all the plant food required for the production of maximum yields of crops on all his fields all the time.

If the farm is a heavy loam and has a practically inexhaustible supply of potash in the soil, then his system of cultivation, rotation, and manuring should be such as to make this potash easily available for the growing crops. If the soil is normally weak in phosphoric acid or lime, the system of farming should provide that the native supply be supplemented by outside sources, usually in the form either of feed for stock with the resulting manure returned to the soil or of fertilizers bought for the purpose.

So, likewise, economy in farming usually demands that the rotation be such that the nitrogen supply of the soil be kept up by the systematic growing of legumes, like clover, in the rotation, though occasionally, with certain crops, artificial supplies may be very profitably used.

Above all, the system of farming must provide an adequate supply of humus for the soil either by growing green-manure crops to turn under or by applying barnyard manure or other by-products of the farm, like straw, stalks, or waste roughage of various kinds. Probably more American farms give decreased yields because of an insufficient supply of humus in the soil than for any other one reason.

So far as we now know, it is not enough simply to follow a rotation of crops on the farm. That alone will not keep up yields permanently. The growing of clover in the rotation, though serving to keep up yields for a considerable period, finally fails, and can not be relied upon for maintaining a permanently productive farm. Something more, in addition to the clover, is needed. That something more is either the intelligent use of commercial fertilizers or the feeding of stock with the crops grown on the farm, supplemented by purchased feeds, and the resulting manure carefully husbanded and returned to the soil with as little loss as possible of plant food.

The cropping system on every farm should be planned so as to meet the demand for increasing productiveness as the years go by. The fertilizing constituents removed from the soil by all of the more common field crops are well known. The materials which may be used to restock the soil with the same constituents are also well known. Crops which may profitably follow each other in the rotation have been ascertained. Satisfactory systems of keeping up the humus supply of the soil have been determined. It simply remains for the farmer, in order to make the farm productive for all time, to fit the crops he desires to grow, in the light of what is already known with reference to good farming methods, into a good rotation and to supplement from some other source any deficiency of plant food or humus in the soil which may occur as a result of growing these crops.

POSSIBLE IMPROVEMENT OF THE SYSTEM.

The system of farming on the estate under consideration was developed by a business man who had to devise methods of management that would seldom require his presence on the farm. This necessarily meant the same or a similar scheme of administration on all the farms. Every farm in the estate is, therefore, run on practically the same plan, regardless of varying soil conditions and the adaptability of the different tenants to such a type of farming. This was the easiest and perhaps the most economical method of handling so large an estate. Nevertheless, it is undoubtedly true that could each farm be operated with reference to the best development of that farm alone, considerably higher yields could be obtained. Strictly high-grade farming should make these farms yield on an average at least 50 bushels of corn and 25 bushels of wheat to the acre. A method of handling that would produce these results, however, implies constant supervision by a thoroughly trained manager, well versed in both the science and practice of agriculture. The very thin stands of clover observed on some farms and the actual results secured on a few farms indicate that in many instances lime or some other soil improver is needed for the best development of the clover crop. It is believed by many farmers in the section of country where these farms are located that lime should be applied at regular intervals.

On some of the farms of the estate having sandy loam soils it is probable that an increase in the potash supplied in the fertilizer would prove beneficial. A skilled manager would also introduce better cultural methods on some of these farms and bring in improved strains of corn and wheat. However, for a scheme of management that relieves the owner of the responsibility of details it would be difficult to devise a better plan than the one already adopted and in operation.

DISTINCTIVE FEATURES OF THE SYSTEM.

The distinctive features of the tenant system described in the foregoing pages follow:

1. The tenant is well provided with a comfortable house and with barns and other outbuildings.

2. He is encouraged to keep live stock and is supplied with equipment for fencing and shelter.

3. He is given all the roughage when he feeds it, but only half when he sells it, thus making it to his interest to feed stock and return the manure to the land.

4. He is under contract to use on certain crops fixed quantities of fertilizers of a specified formula; the quality of this fertilizer is guaranteed by the estate.

5. He must sow a given quantity of clover seed each year. This is to his advantage, as he gets the crop either for pasture or for hay, and in addition he receives the benefit of it as a soil renovator. To their own disadvantage, many farm owners neglect to sow clover when the price of seed is high or for other reasons. Under this tenant system such neglect is made impossible without violating the contract. Herein is one advantage this system may have over systems usually followed by owners.

6. He takes an interest in the farm on account of his belief in the fairness of the contract and in the permanency of his tenure.

SYSTEMS FOR TENANT FARMS.

1. A good system, with reference both to rotation and the maintenance of soil fertility, is essential to a permanently profitable farm.

2. Tenant farms are especially liable to decrease in productiveness as the years go by because of the general lack of an adequate system for maintaining their soil fertility.

3. Plans for farming are possible whereby both tenant and owner can make a fair profit and the farm still be kept permanently productive.

4. The owner should make the plan, since he is the one most vitally interested in the continued productiveness of the farm.

5. The plan should be based on: (*a*) A rotation of crops which of itself will keep up the humus and nitrogen supply of the soil over the whole farm; (*b*) a manuring or fertilizing system which will keep the soil adequately supplied with phosphorus, potash, and lime; (*c*) a division of the expenses and the returns of the farm which shall be fair to both owner and tenant; (*d*) terms of rental which shall induce permanent tenure; and (*e*) a simple system easily understood and easily carried out, based on crops and practices best adapted to the locality.

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Issued April 15, 1911.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 438.

HOG HOUSES.

BY

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WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Animal Industry,
Washington, D. C., January 20, 1911.

Sir: I have the honor to transmit herewith and to recommend for publication as a Farmers' Bulletin a manuscript entitled "Hog Houses," by Mr. J. A. Warren, formerly of the Office of Farm Management, Bureau of Plant Industry.

The paper deals especially with a subject that is of great importance to hog raisers, namely, the sanitary and economical housing of the animals.

The question of location of windows to provide the maximum amount of sunshine in the pens at farrowing time is particularly well developed by Mr. Warren, and in this connection is given a sunshine table based on astronomical calculations, for which the author is indebted to Prof. Milton Updegraff, in charge of the Nautical Almanac of the United States Naval Observatory.

Respectfully,

A. D. Melvin,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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HOG HOUSES.

INTRODUCTION.

In the corn belt hogs furnish one of the most important means of marketing the corn crop. With the exception of chickens, they are the most numerous of all farm animals, and are grown for market on more farms than any other stock. Hog raising has probably made more clear money for the corn-belt farmers than any other enterprise. In view of this one might expect to find hogs the best housed of any animals on the farm, but the opposite is the case. It is still hard for many farmers to get rid of the notion that anything is good enough for a hog. Yet there is no animal on the farm which requires better protection from cold than the hog; none for which a good bed is more necessary; and none so much in need of sunshine as the little pig. The horse and the cow have good coats of hair—even a calf or a colt when left in the cold is provided with a good fur coat; the hen's feathers are the best of protection against cold; but the hog has almost nothing between his skin and the weather.

One of the first requisites for success with hogs is a shelter where young pigs can be kept warm and well supplied with sunshine and fresh air. A little pig takes cold very easily and recovers slowly if at all. To prevent taking cold he must be kept dry, warm, away from drafts, and provided with fresh air.

Most good hog raisers who have warm buildings try to have their sows commence farrowing about March 1, but without good houses this is impracticable. Breeders find it necessary to have their pigs come about this time in order to have them large enough for the fall demand, and producers of market hogs find the practice profitable. Early pigs have several marked advantages. In the first place, there is usually more time to care for them early in March. Early March pigs are large enough to begin to eat as soon as pasture is ready and thus get the longest possible pasture season, and can be expected to make more pork from grass than is possible for later pigs. They can be kept on pasture until ready for market, or nearly so. Not only can they make more use of pasture but they can make more economical use of all feed because they can be finished for market before the cold weather of winter sets in, when gains are more expensive. If these pigs are crowded, many of them can be marketed by the last of October, and for the last 10 years the Omaha price for October has averaged 58 cents higher than for December. Without a good house two litters a year can not be raised to advantage, because the spring pigs must be put off until so late that the fall litters do not get well started before cold weather, but with a good house two litters can well be raised. Most farmers do not feel that they can keep an old sow for one litter, but with two litters it becomes a different proposition. It is universally conceded that old sows raise better pigs than young ones, and the keeping of old sows enables one to select and keep only the best producers.

PREVAILING CONDITIONS POOR.

On the average, the hog house is the poorest building on the farm and the least adapted to the purpose for which it was intended. Good barns may be seen on a large proportion of the farms, but good hog houses are generally hard to find. It is economy to put up first the buildings that will help most to make money. A large portion of the farmers recognize this and build a good barn before putting up a good house, saying "The barn will help build the house but the house will never help build the barn." This principle seems to be lost sight of when it comes to the hog house, yet no other building on the farm pays for itself so quickly. Unpublished data collected by the writer show that good hog men average about seven pigs raised to the litter and many surpass this record. The same data indicate that the general average raised on the farm does not exceed four pigs to the litter. This wide difference is very largely due to the housing.

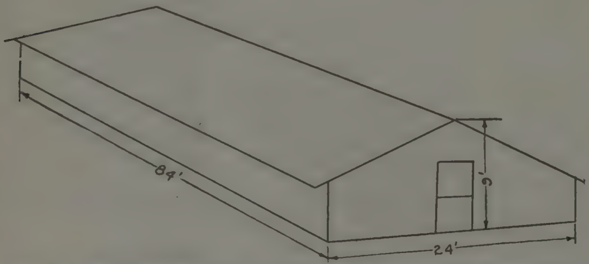


FIG. 1.—A poor hog house; no provision for light or ventilation.

Many houses which cost enough to be good are thoroughly unfit for the purpose because the sun can not shine into the pens. Nearly every large hog house is deficient in either sunshine or ventilation, or in both.

The diagram, figure 1, represents a farrowing house seen on one of the most highly improved farms in southern Nebraska. To replace the buildings on this farm would cost $12,000 or $14,000. The hog house is the nearest building to the house, and stands almost between it and a large, modern horse barn. This hog shed is 24 feet wide and 84 feet long. There is not a window or ventilator in it, the only means of admitting air and light being the alley doors and a few small hog doors. A more unsuitable structure could hardly be devised.

The writer has personal knowledge of another hog house quite similar to this but only about half as large, the only openings being one alley door, one hog door, and one small window. In this house over 90 per cent of the early pigs were lost in some seasons, mostly from thumps. The loss in a single season would have more than paid for a good building.

A little pig loves sunshine and needs it almost as much as he needs food. No piggery is fit for the purpose unless it admits direct sunshine onto the floor of every pen at the time the pigs are farrowed, furnishes plenty of fresh air, and provides for exercise in the open air. Dryness, sunshine, warmth, fresh air, freedom from drafts, and exercise are of primary importance in raising pigs. These secured, the battle is half won. In putting up buildings the six requirements just mentioned must be kept constantly in mind; not one can be neglected.

COST OF HOUSING PIGS.

What is the necessary cost of housing a litter? Where lumber is $25 to $35 a thousand, good single-walled houses need not cost over $10 to $20 a pen, and double-walled $20 to $30 a pen. It is doubtful economy, under most conditions, to make them cost over $30 a pen, and very good sheds are sometimes made for less than $10 a pen. It is easy to get too much expense into any building, and the hog house is no exception. No one can afford for any purpose a building so expensive that interest and depreciation will eat up its usefulness. The owner of a new hog house once showed it to the writer with considerable pride. The building was equipped with conveniences of the best sort and appeared to be ideal in every respect except one—cost. It contained 18 pens besides the feed bins, and cost, according to the contractor, approximately $4,000, or $222 a pen. The interest on this investment at 5 per cent amounts to $11.10 for every sow pen, and the annual cost of each pen, including interest, depreciation, repairs, and insurance, would be about $27, which, as has been shown, is amply sufficient to pay for a good pen outright; or, at average Omaha prices ($5.50 per hundredweight), it would take two 250-pound hogs every year to pay for the maintenance of a single sow pen. It is hard to see how such a building can ever pay for itself.

By careful management it is not difficult to make each pen accommodate three litters a year. Taking $25 as the cost per pen (which is sufficient to make a good double-walled building), we have the following:

Interest on investment ($25), at 5 per cent	$1.25
Insurance, at 50 cents per $1,000	.0125
Repairs, 1½ per cent	.375
Depreciation, 5 per cent	1.25
Total	2.8875

Using each pen for three litters a year, the cost of housing one litter would be slightly less than $1. This is about what one pig has cost when farrowed. Or, with the high prices that have prevailed for several years, one pig at weaning time would pay for the use of one good pen a whole year, which would accommodate three litters, averaging seven pigs or more each. Of course, more shed room is required for the older hogs, but this may be of much cheaper construction. If only one litter a year is raised, no other shed would be needed. Many farmers have provided usable structures for less than half the above figures.

VARIETIES OF HOG HOUSES.

The variety of hog houses is almost as great as the variety of individuals using them. It is rare, indeed, to find even a semblance of uniformity prevailing in a community. There are, however, only two or three general types which commend themselves to the careful hog man. Of the two styles of large houses, the larger has two rows of pens, an alley through the middle, and a jog in the roof for windows to light the north pens, while the smaller has but one row of pens, with an alley and a row of windows on the south side. The double house is much cheaper per pen, and for that reason is to be preferred. Less work is also required to care for the hogs than where a single row of pens is used.

Probably the cheapest house possible is a low building with a single row of pens and no alley (see figs. 13 and 14), but such a house is much less convenient, especially in stormy weather. In northeastern Kansas and southeastern Nebraska there are a number of houses with common gable roofs which are lighted by rows of glass extending from the ridge of the roof to the plate. This seems an awkward method of securing sunshine and has nothing particularly in its favor.

A large hog house should always stand east and west, facing the south, so that the maximum amount of sunshine may be had in each pen. When a double house is used, which is much the cheapest, the outside pens on the north are often of little use in early spring and late fall on account of the shade and the cold winds. This difficulty can be partially overcome by changing sows so that those which have not farrowed and those with the oldest pigs, which have least need of warm outside pens, are on the north side. This problem has been ingeniously solved by a prominent Duroc breeder whose hog house is later described in detail. (See figs. 9 and 10.)

In the majority of large hog houses the upper windows are not so placed that the sunshine will strike the floor when it is most needed there. Indeed, a hog house with the windows in the proper position is rarely seen. Direct sunshine should strike the floor in every pen for as many hours in the day as possible at the time when the pigs are farrowed. Nearly every one realizes this is a matter of the greatest importance, but too often the builder does not take the trouble to find out whether he is getting it or not. Ordinarily the farmer has no means of ascertaining where to put the windows so as to get the maximum amount of sunshine at the time he wants it, unless he happens to be building just at that time, which is very unusual. The country is dotted with hog houses in which the owner thought he was putting the windows where he wanted them, but found later they were in the wrong place.

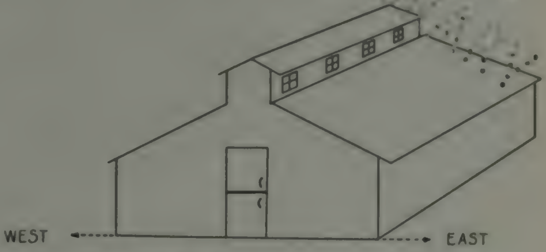


FIG. 2.—A common but unsatisfactory type of hog house; insufficient light, and stands north and south instead of east and west.

In double houses the windows for lighting the south pens must be as high up as possible in order to get them away from the hogs.

EXAMPLES OF FAULTY CONSTRUCTION.

Figure 2 is an outline of one of the commonest types of hog house in many communities, but utterly unfit for the purpose. This type of house almost always stands north and south. Very little sunshine ever strikes the floor, and as a consequence the pens are often damp and chilly.

The building shown in figure 3 is about 30 miles north of the fortieth parallel. It is well built and of the best material on the market. It is 22 feet wide, 42 feet long, contains fourteen 6 by 8 pens, and cost, approximately, $250, or $17.86 a pen. Figure 4 is a cross section of figure 3, showing where the sun's rays will strike at noon March 1. It will be seen that there can be no appreciable amount of sunshine on the floor of the north pens until about the middle of the month. In this case the common mistake was made of placing the windows too high above the floor and thus impairing the usefulness of the north pens. The walls should have been lower and the south roof flatter, so as to lower the upper windows.

The hog house shown in figure 5 is near the fortieth parallel. The north roof is shingled; the south roof has patent roofing. Inside pens are 7 by 12 feet. The back half of the pens is floored with plank, the front half and alley with concrete. This is a very good house, especially if one wants to feed inside. The upper windows, however, are too low for the width of the house. It is true the windows are in right position for farrowing on February 1, but if the pigs are wanted a month later, then, as the diagram (fig. 6) shows, the sunshine will be on the concrete floor a large part of the day March 1, and much more of the time later in the season. This will induce the pigs to lie on the concrete and cause them to take cold. Another set of windows higher up would correct the error, and should be put in.

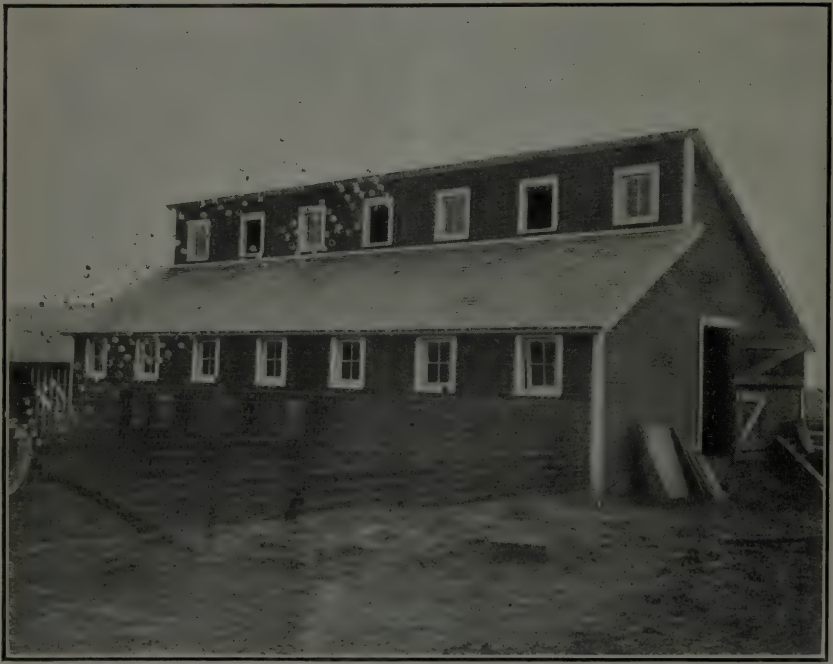


FIG. 3.—A substantial building, but with upper windows too high for locality where built unless late farrowing is desired.

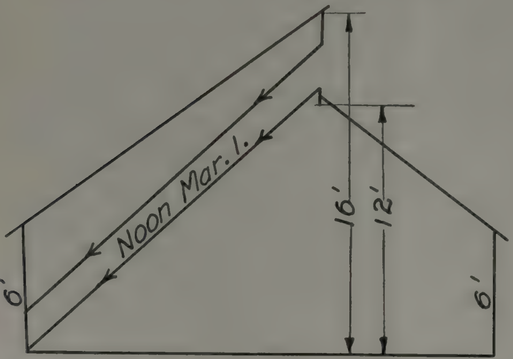


FIG. 4.—Cross section of house shown in figure 3, showing where sunshine from upper windows will fall at noon March 1.

TWO WELL-BUILT HOG HOUSES.

Figure 7 shows a hog house built in south-central Nebraska in 1909. The walls are unmatched sheathing, paper and lap siding. The roof is shingled. This house is 24 by 40 feet, and contains ten 8 by 10 pens. The cost of material was $260, labor $60, total $320, not including foundation, or $32 a pen. Including the foundation, the cost must have been at least $36 a pen. The middle window of each group of three swings on stops for ventilation. The inside fences are 33 inches high and are made of four 1 by 6 and two 2 by 4 pieces. One 2 by 4 is laid flat on top.

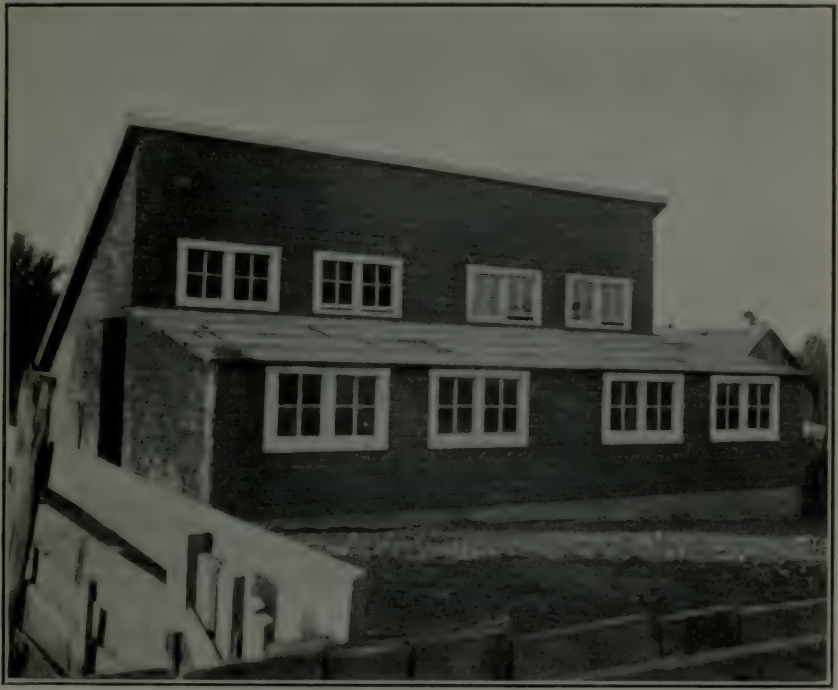


FIG. 5.—A building in which the upper windows are too low for farrowing March 1—an uncommon mistake.

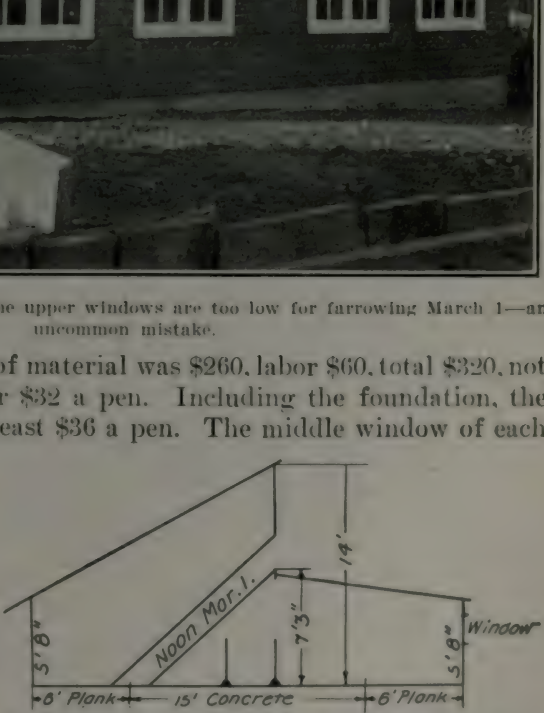


FIG. 6.—Cross section of house shown in figure 5, showing where sunshine from upper windows will fall at noon March 1.

Figure 8 is a cross section of the house shown in figure 7, showing where the sunshine will strike at 10 a. m. March 1. This shows that the sunshine from the full length of the window will strike the floor over four hours a day March 1.

This is a good hog house, but rather expensive. The pens could as well have been 6 feet wide instead of 8, and the cost per pen would thus have been reduced almost one-fourth. The usefulness would be improved by the addition of outside pens. The owner is a hog man of long and successful experience. He has used both individual and two-hog cots for many years, but has now supplemented them with this large house.

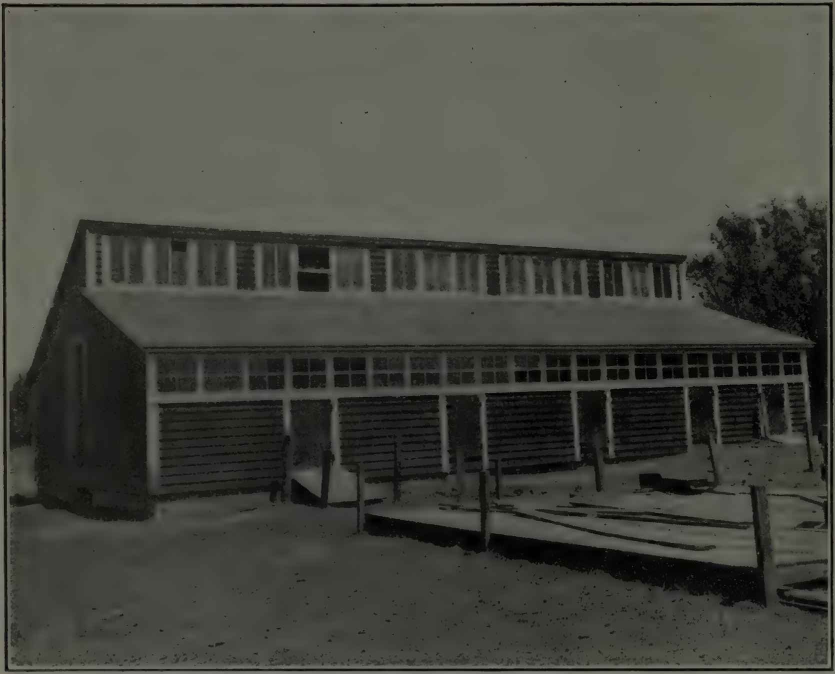


FIG. 7.—A hog house with upper windows perfectly arranged for farrowing March 1.

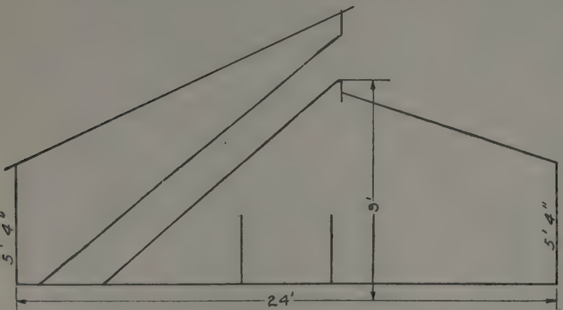


FIG. 8.—Cross section of house shown in figure 7, showing where sunshine from upper windows will fall at 10 a. m. and 2 p. m. March 1.

Figures 9 and 10 represent a house built by one of the most prominent Duroc breeders after careful study. It is a most serviceable structure and one of the best the writer has ever seen. It is one of the few hog houses that have proved so satisfactory that the owners are willing to duplicate them. This house has been copied by a number of farmers in the vicinity, some of whom, however, have made the mistake of building a longer house and not making provision for outside pens for the extra inside pens.

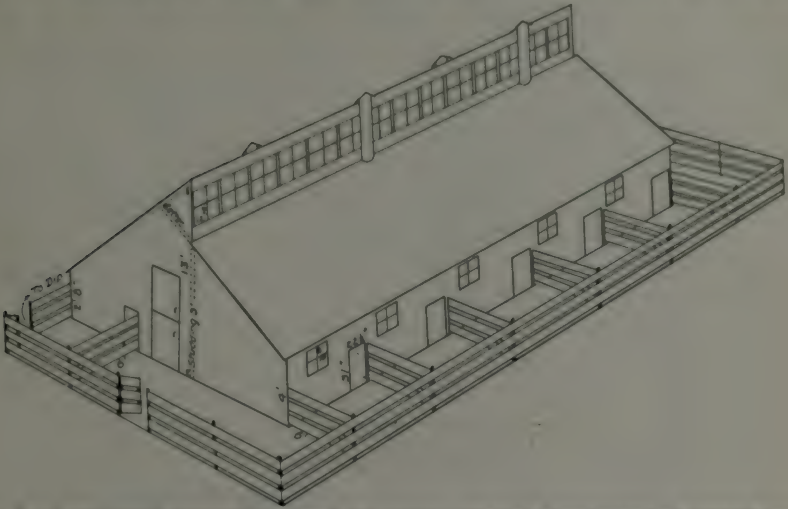


Fig. 9.—A well-built and well-arranged hog house, showing arrangement of outside pens.

The walls are sheathed, papered, and sided. The roof is shingled. The outside floors on the east, west, and south are 6 feet wide. This house is 22 by 36 feet and contains ten pens. It was built north of Omaha in 1905 and cost, complete, including labor, $275, or $27.50 a pen. This includes the outside floor and pens.

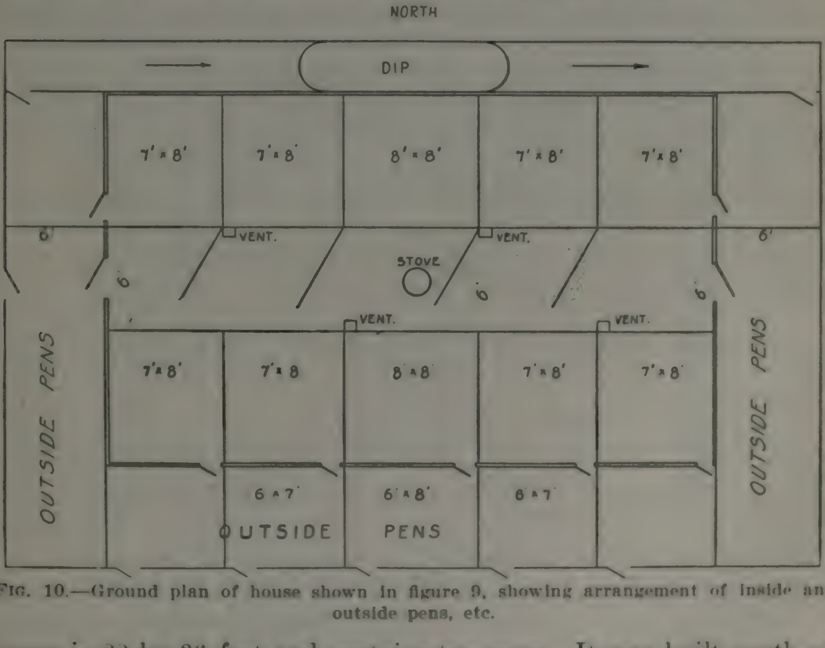


Fig. 10.—Ground plan of house shown in figure 9, showing arrangement of inside and outside pens, etc.

The gates across the alley all lift off their hinges so they can be removed or replaced in a moment. This arrangement makes it very convenient in sorting hogs to change them from one pen to another or to make extra pens when crowded. When swung across the alley the free ends of the gates fasten with common house-door bolts. By putting these on so the knobs turn up instead of down, the owner finds that hogs can not open them. If the knobs turned down the hogs could open them readily. The fronts of the pens next the alley are all loose panels which lift out. In this way the whole house can be made into one large room in a few minutes, nothing but the pen partitions being left in place.

The inside pens are 7 by 8 feet, except the middle one on each side, which is 8 by 8 feet. (The pens are irregular in width because the lumber cut this way to better advantage.) The hog doors are 22½ by 31 inches in the clear. The large doors are 3 by 6 feet, divided in the middle. The upper windows each contain four 12 by 14 inch lights and are set solid and close together. The lower windows each contain four 10 by 12 inch lights.

The most striking feature of this house is the ingenious way in which outside pens have been provided without having them on the north side. There is an outside pen for every inside pen except one, the sows on the north side going out as indicated by the arrows in figure 10. This could not be accomplished with any more pens.

The ventilators are 6 by 6 inches inside. The lower ends are 2 feet above the floor and the upper ends just above the comb of the roof. The south rafters are extended to meet the north rafters so that no studding are needed under the south edge of the north roof (see fig. 9). Whether this gives any advantage is doubtful. The sunshine will strike the floor in all pens several hours a day on March 1.

The dipping tank is convenient, but in a cold place. Perhaps this could be bettered.

A COMBINATION HOG HOUSE WITH HAY AND GRAIN STORAGE ROOMS.

It is a great convenience to have grain bins and storage room for bedding and hay in the hog house. In some houses similar to those described above such space has been provided by simply extending the building. A modification of the double house, which provides storage room and contains several other excellent features, is described below.

Figures 11 and 12 show the plans of a hog house built by a very successful grower of market hogs in western Iowa in 1906. It has now been in use four years and has given the owner excellent satisfaction. It contains 24 pens, each 5 by 9 feet, a covered feeding floor, bins for grain, tankage, and oil meal, and mow room for hay and bedding. The material cost, approximately, $400. The labor was all performed by the regular farm help and no account of it was kept. In this house a large number of hogs can be cared for with a very small amount of work. The high roof of the central part shuts off a portion of the sunshine from the sow pens. This is a bad feature, but one which could not be avoided without sacrificing the feeding floor and the convenience of the interior arrangement. This shading of the sow pens seems to the writer a very grave error, but

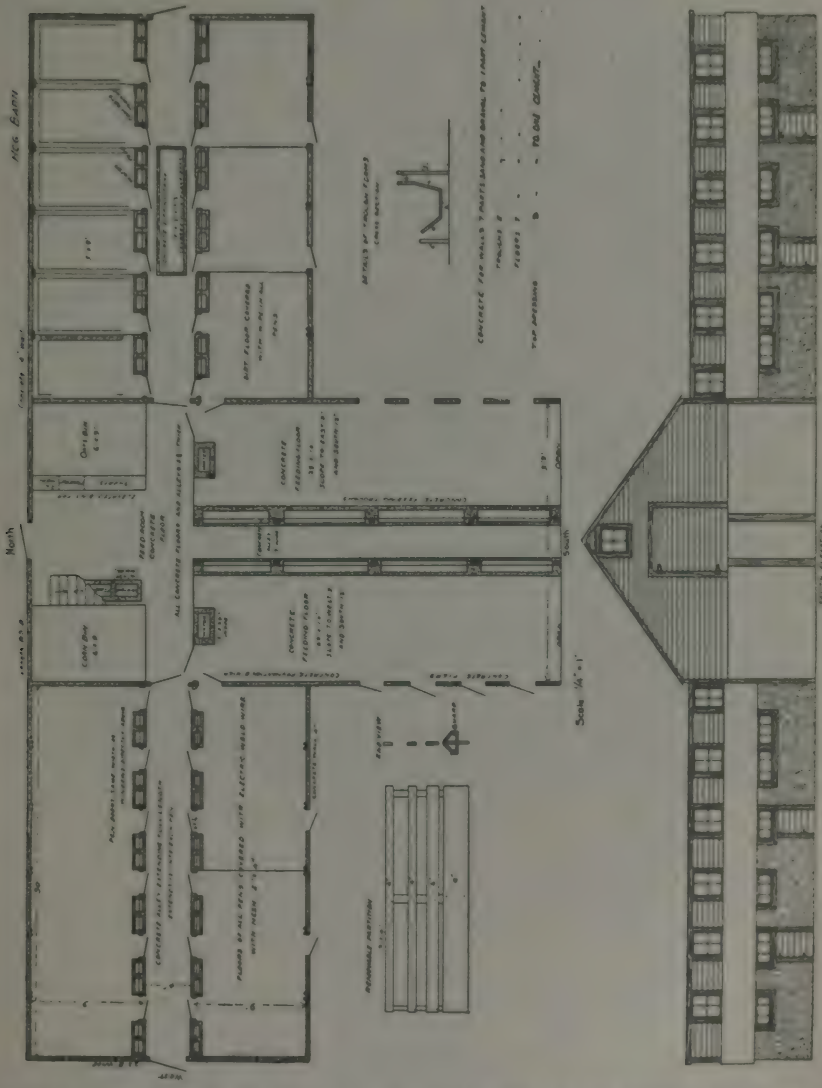


FIG. 11.—A combination hog house, with hay and grain storage rooms.

the owner, after four years of experience, does not consider it very serious. Of course, even the pens next to the central part get the benefit of the sunshine somewhat more than half of the day. But it is evident that the windows nearest the central part of the building throw sunshine on the floor only a very short time. They would be much more useful if they were several feet from the high building. The owner now regrets that he did not make a solid row of windows both above and below.

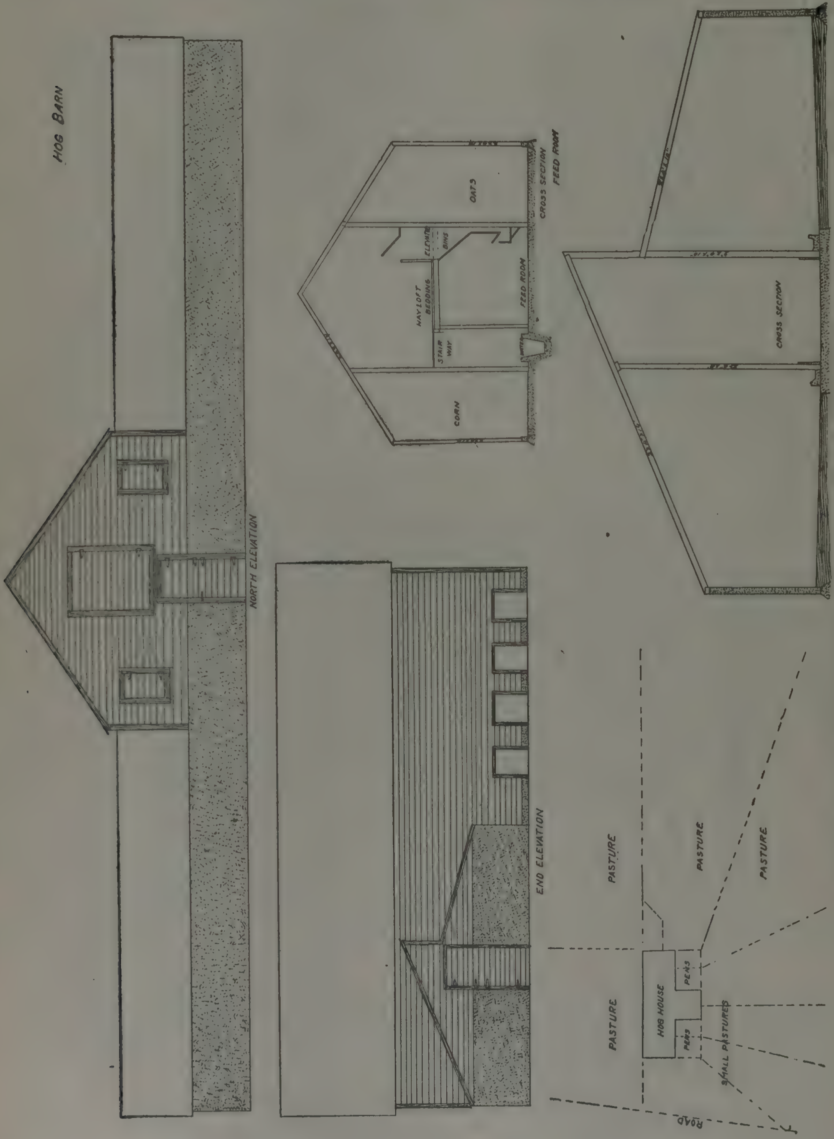


Fig. 12.—Cross sections and elevations of house shown in figure 11.

Shed cots are used in connection with this house, the sows being moved out generally when the pigs are about two weeks old.

TWO TYPES OF CHEAP HOUSES.

Figure 13 shows a cheap house, but lacking in light and ventilation when the roof doors are closed. It is 6 by 48 feet and contains 8 pens, each 6 by 6 feet. The material (not including outside pens or posts) cost $48, or $6 a pen. Figure 14 shows the end elevation.

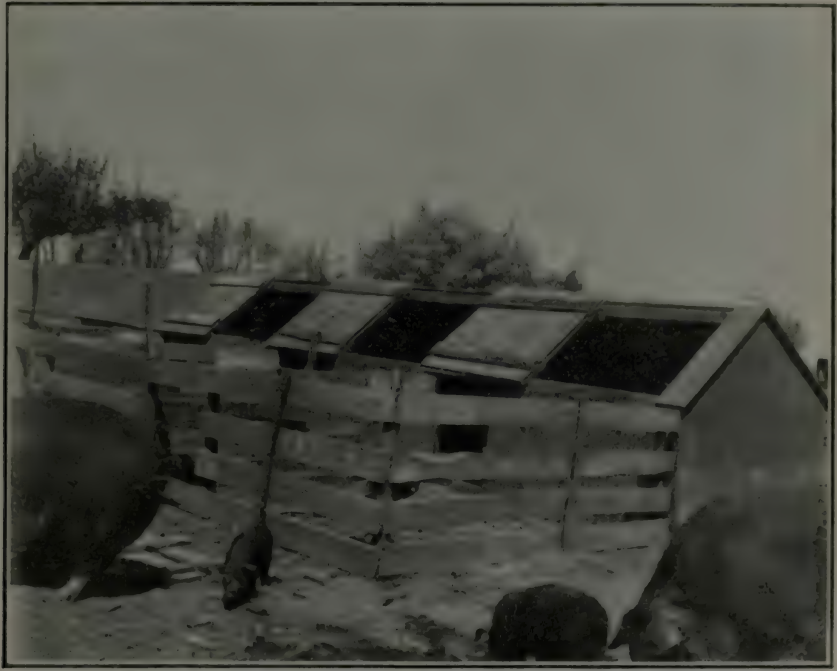


FIG. 13.—A very cheap hog house, but lacking light and ventilation when roof doors are closed.

Figure 15 shows a much better house of the same general type. It contains sixteen 5 by 7 pens. The material cost (in southeast Nebraska, 1907) is $115, or $7.19 a pen.

HOG COTS OR INDIVIDUAL HOUSES.

Whether the large house with individual pens is better than the individual cot is an open question, perhaps largely a matter of individual preference. Each has its distinct advantages which can not be secured in the other. Many of the best hog raisers are now providing themselves with both types of houses, and this seems to be the most satisfactory method. It is no more expensive in the long run, for all the buildings can be kept in use the year round. In such cases the large houses are used for farrowing quarters, and as soon as the pigs are a week or two old, or as soon as the weather permits, the sows and litters are removed to the individual cots. During the remainder of the year the large houses are utilized for sleeping quarters.

The small cot has the advantage of keeping each sow from the disturbance of the others, and lessens the danger from contagious and infectious diseases. The disturbance in a large house, however, is usually not a serious matter and is often unduly emphasized. After the pigs get a little start there is usually more or less robbing where many are together. The individual cot lessens this trouble. When the surroundings become insanitary, the cot can easily be moved to a clean place.

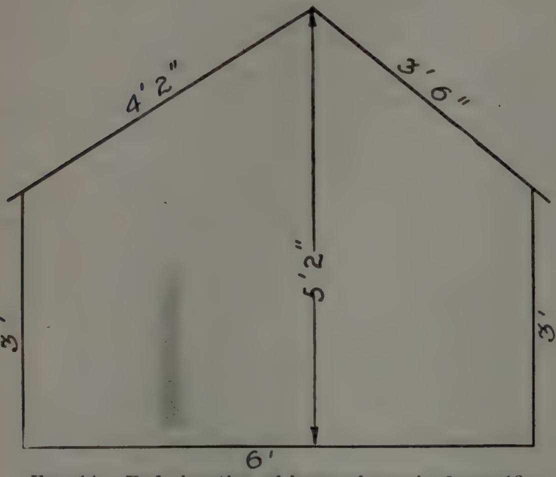


Fig. 14.—End elevation of house shown in figure 13.

Probably the greatest disadvantage in the cot is the large amount of work required to tend the stock. This is a matter of no small importance. There are usually no windows, so there is no sunshine or light when the roof door is closed. There is, however, no reason why windows and ventilation should not be provided. The open roof which is commonly used places the pigs in more danger of being chilled by cold winds and sudden storms when the attendant is away. Unless the cot is unusually well built, it is somewhat more difficult to keep warm in very cold weather than the large house.

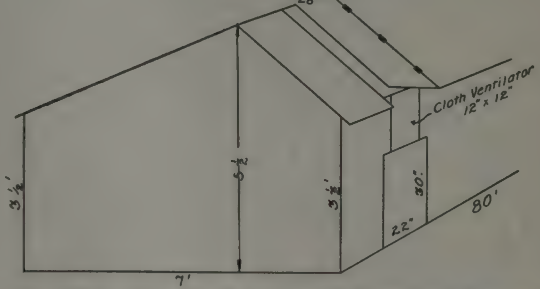


Fig. 15.—A cheap but serviceable house—an improvement on that shown in figures 13 and 14.

The main advantage in the large house lies in the convenience with which the stock can be tended and the short time required to see all the animals. It is somewhat more easy to keep warm, and is more easily heated if artificial heat is required. During cold days the pigs can get the sunshine, if there is any, without any exposure whatever.

The variety of individual hog houses is greater, if anything, than that of large houses, but they are readily separable into two general classes—the Λ-shaped cot, and the various cots with perpendicular sides. The Λ-shaped cot is quite satisfactory when well built and provided with a window and ventilating door, but generally these are lacking. Nearly all of the cots with perpendicular sides have doors in the roof or in the south side to be opened in sunny weather. It is easier to care for sows in these houses than in the Λ-shaped cots. All cots should be built on skids. Some of the best types of cots are described below.

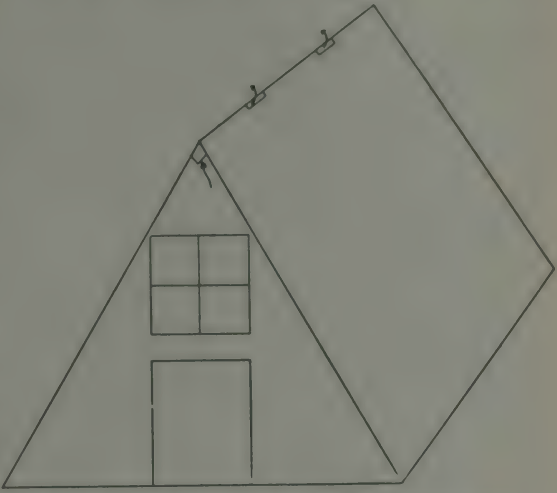


FIG. 16.—The Lovejoy individual hog house or cot.

Figure 16 represents one of the best styles of Λ-shaped cots, commonly known as the Lovejoy cot. In 1904 the Nebraska Hospital for the Insane, at Lincoln, built a number of these cots. All the walls are double, being sheathed, papered, and then covered with flooring. The doors are also double. These cots cost about $40 each. Less substantial cots of the same shape may be built for much less money.

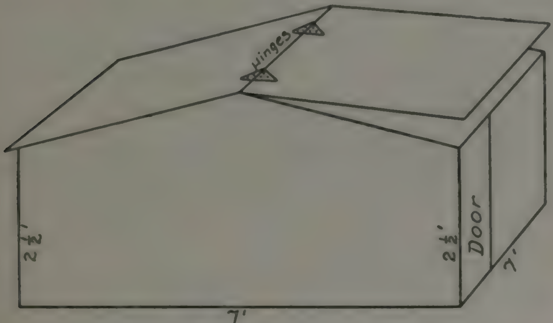


FIG. 17.—A square cot, with hinged roof.

Figure 17 shows a good type of cot in use in southeastern Iowa. The whole south roof is on hinges and can be laid over on the north side. The front wall is a loose panel, which can be quickly removed. The floor is also removable. There are no projections on the ends in order that the cots may be set close together in winter. They are moved by raising and putting a sled underneath.

Figure 18 shows a good cot in south-central Nebraska, with a convenient knockdown pen. Skids 4 by 6, 9 feet long. Joists 2, 2 by 6, laid flat. Walls shiplap, paper and lap siding. Roof doors 18 inches wide. Cost complete, $25 (1908). Figure 19 shows the dimensions of the house and also the panels of the pen.

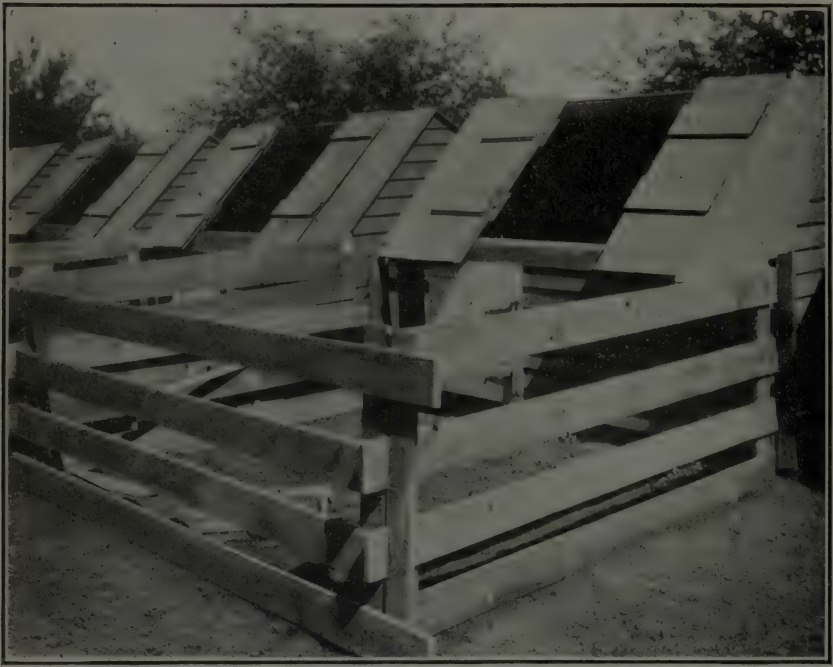
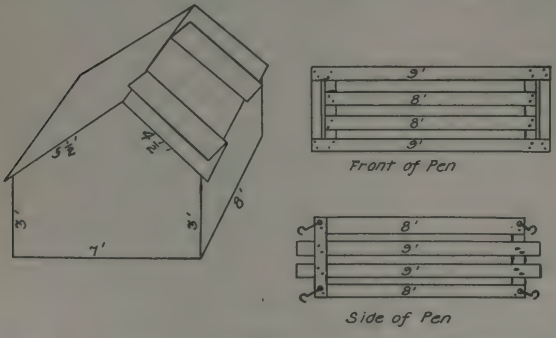


FIG. 18.—A good individual house, with knockdown pen.



Front of Pen

Side of Pen

FIG. 19.—Diagram of individual house shown in figure 18, showing dimensions and details of pen construction.

HINTS ON CONSTRUCTION.

FLOORS.

The hog-house floor is an unsettled question. · A good floor is the ground with woven wire stretched on top to prevent the hogs from rooting. Electrically welded corncrib wire is very satisfactory. This makes a floor which is easy on the hogs, almost free from rats, and, if properly bedded, warm and dry. It is, however, more difficult to keep free from dust than some other floors. Many concrete floors are used, but they are cold, liable to be wet, and are hard on the hogs' feet. Often almost an entire pig crop and many sows are lost by taking cold on concrete floors. Concrete floors are, however, very satisfactory when covered with plank overlays, or false floors, which should be raised from the concrete about an inch by nailing cleats on the under side, as shown in figure 20. The wood portion of this floor consists of 2 by 4 inch timbers laid about one-fourth inch apart to allow drainage.

Board floors are expensive, short lived, cold if up off the ground, and make the worst kind of rat harbors. The writer once visited an old hog house with wood floor in which the owner said the rats had gotten over half the pigs. Several men report that rats may be kept out by packing sand or cinders to the top of the joists before laying the floor, but these materials are often too expensive to be used for this purpose.

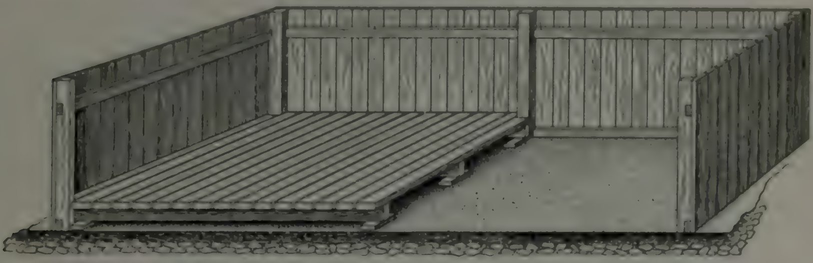


FIG. 20.—Pen, showing concrete floor with removable wood overlay.

PARTITIONS.

In making the inside partitions, care should always be taken to have them perfectly tight at the floor and for about 10 or 12 inches above, so that young pigs can not crawl through, and so sows in the adjoining pens can not get hold of them and pull them through. A sow will often pull a newly born pig through under a partition and eat it, when, if the pig was in the pen with her, it would be perfectly safe. Above the first 10 or 12 inches it is better to have the partitions open enough so the hogs can see out, otherwise at every sound the sows will be up on the partitions to see what is going on.

Pig rails or guardrails should be placed on the inside of the pen, from 6 to 10 inches from the floor, according to the size of the sow, and should stand out 6 or 8 inches to prevent the sow from mashing the pigs against the wall.

It will be found convenient to have the alley gates removable by lifting out. It is sometimes helpful, also, to have part or all of the partition fences removable. All partitions should be 30 to 36 inches high.

Six by 8 feet is generally found to be a very satisfactory size for pens, but if feeding is to be done inside, the pens will need to be longer in order to give room to feed and water without getting the bed befouled. Very large sows, such as are sometimes kept by breeders, may need more room, but the producer of pork will not need a larger pen. Small sows do not need this much room, and it might be good economy to make half of the pens 5 feet wide. Five by 8 feet will accommodate a small sow very well.

Hog doors should be 22 to 23 inches wide and 30 to 31 inches high in the clear. In cold weather a piece of burlap or ducking hung at the top of the hog door, with a stick a little shorter than the width of the door nailed across the bottom to prevent the wind from blowing it back, will help materially to keep the pigs warm. The pigs will soon learn to lift the curtain when they want to go through. The board doors in cots would not then need to be closed except in very bad weather, or while the pigs are very small.

VENTILATION.

In most cases, either ventilation is lacking or the house is drafty. In a well-ventilated, double-walled building, little moisture will gather on the walls even in very cold weather, while in a poorly ventilated one thick coats of frost will often gather, and the whole house will be damp when the frost melts. It is not easy to secure a good supply of fresh air and prevent all drafts from striking the pigs. There are, however, several quite satisfactory methods of ventilation in use. The commonest one is to make some of the windows so they will either slide or swing on hinges. The box ventilators shown in figures 9 and 10 are very satisfactory. The cloth curtain window also does good work.

WHITEWASHING.

Whitewashing the inside of the house is an excellent practice. Besides going a long way toward disinfecting, it increases the light materially. When the sunshine strikes a whitewashed wall, much of it is reflected to the floor and does a great deal of good. Dark houses which must be used will be much improved by whitewashing.

WHERE TO PLACE WINDOWS IN HOG HOUSES.

The following tables, prepared at the United States Naval Observatory, will enable the reader to determine at once how the windows in a hog house should be placed in order to secure the maximum sunshine in the pens at any desired time from January to May. The tables show the height (at top) necessary for windows to be in order that the sun may strike the back line of the floor of the pen—at the given distances north of the window—at 10 a. m., noon, and 2 p. m., on the first day of each month from January to May, inclusive. The calculations are made for every 2 degrees of latitude from 30 to 48 degrees north, and for distances north of the window from 4 feet to 18 feet. This covers all ordinary widths of buildings and all parts of the United States. It is assumed, of course, that the windows front due south.

The outline map of the United States (fig. 21) shows what parts of the country are crossed by each of the parallels mentioned in the tables. By referring to the map anyone can tell approximately what his latitude is, and thus can see what figures in the tables apply to his locality.

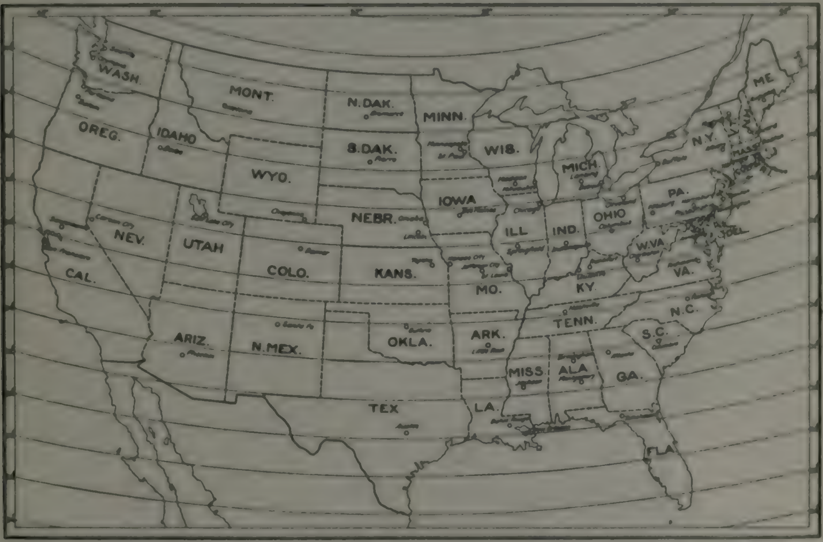


FIG. 21.—Outline map of the United States, showing even parallels of latitude from 26° north to 48° north.

HOW TO USE THE SUNSHINE TABLES.

Suppose a farmer lives at Springfield, Ill., and wishes to put up a hog house 20 feet wide, having pens 8 feet long and the alley 4 feet wide (after the general style of the houses shown in figs. 5 and 7), and wants the pigs to come about March 1. In this case the combined length of the pen and width of the alley (12 feet) represents the distance from the line of the upper windows to the back line of the rear pens. Consequently, in order to locate the proper height for the upper windows he turns to the table under "March 1," finds latitude 40, follows the line across to the column headed "12 feet," and there finds that the top of the window should be 10 feet 6 inches from the ground in order to get the sunshine on the back line of the pen at 10 a. m. and at 2 p. m. In this instance it will be noted that the sun, being a little higher at noon, does not quite strike the back line at that hour, but goes back there by 2 o'clock.

It may be seen from the above example that under normal conditions—that is, avoiding extremes of latitude and of season—the information given in the tables is of much practical value. Where, however, we take Florida for May 1, or northern Minnesota for January 1, we find conditions that are not practicable, because in the first case the windows would have to be too high and in the second too low.

JANUARY 1.

Latitude.	Distance from window line (at floor) to north end of pen.							
	4 feet.		6 feet.		8 feet.		10 feet.	
	Noon.	10 a. m. and 2 p. m.	Noon.	10 a. m. and 2 p. m.	Noon.	10 a. m. and 2 p. m.	Noon.	10 a. m. and 2 p. m.
	Height of window.							
	Ft. in.	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*
30 degrees N..........	3 0	2 8	4 6	4 0	6 0	5 4	7 6	6 9
32 degrees N..........	2 10	2 6	4 2	3 9	5 7	5 0	7 0	6 3
34 degrees N..........	2 7	2 4	3 11	3 5	5 2	4 7	6 6	5 9
36 degrees N..........	2 5	2 1	3 7	3 2	4 10	4 2	6 0	5 3
38 degrees N..........	2 3	1 11	3 4	2 11	4 5	3 10	5 6	4 10
40 degrees N..........	2 0	1 9	3 1	2 8	4 1	3 6	5 1	4 5
42 degrees N..........	1 10	1 7	2 10	2 5	3 9	3 2	4 8	4 0
44 degrees N..........	1 8	1 5	2 7	2 2	3 5	2 11	4 3	3 7
46 degrees N..........	1 6	1 3	2 4	1 11	3 1	2 7	3 10	3 3
48 degrees N..........	1 5	1 2	2 1	1 8	2 9	2 3	3 5	2 10

Latitude.	Distance from window line (at floor) to north end of pen.							
	12 feet.		14 feet.		16 feet.		18 feet.	
	Noon.	10 a. m. and 2 p. m.	Noon.	10 a. m. and 2 p. m.	Noon.	10 a. m. and 2 p. m.	Noon.	10 a. m. and 2 p. m.
	Height of window.							
	Ft. in.	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*
30 degrees N..........	9 0	8 1	10 6	9 5	12 0	10 9	13 6	12 1
32 degrees N..........	8 5	7 5	9 9	8 8	11 2	9 11	12 7	11 2
34 degrees N..........	7 9	6 11	9 1	8 0	10 4	9 2	11 8	10 4
36 degrees N..........	7 2	6 4	8 5	7 5	9 7	8 5	10 10	9 6
38 degrees N..........	6 8	5 10	7 9	6 9	8 10	7 9	9 11	8 9
40 degrees N..........	6 1	5 4	7 2	6 2	8 2	7 1	9 2	7 11
42 degrees N..........	5 7	4 10	6 6	5 7	7 5	6 5	8 5	7 3
44 degrees N..........	5 1	4 4	5 11	5 1	6 9	5 9	7 8	6 6
46 degrees N..........	4 7	3 10	5 4	4 6	6 2	5 2	6 11	5 10
48 degrees N..........	4 2	3 5	4 10	4 0	5 6	4 7	6 2	5 1

FEBRUARY 1.

Latitude.	Distance from window line (at floor) to north end of pen.							
	4 feet.		6 feet.		8 feet.		10 feet.	
	Noon.	10 a. m. and 2 p. m.	Noon.	10 a. m. and 2 p. m.	Noon.	10 a. m. and 2 p. m.	Noon.	10 a. m. and 2 p. m.
	Height of window.							
	Ft. in.	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*
30 degrees N.	3 8	3 5	5 7	5 1	7 5	6 10	9 3	8 6
32 degrees N.	3 5	3 2	5 2	4 9	6 11	6 4	8 8	7 11
34 degrees N.	3 3	2 11	4 10	4 5	6 5	5 11	8 0	7 4
36 degrees N.	3 0	2 9	4 6	4 1	6 0	5 6	7 6	6 10
38 degrees N.	2 9	2 6	4 2	3 10	5 7	5 1	6 11	6 4
40 degrees N.	2 7	2 4	3 10	3 6	5 2	4 8	6 5	5 10
42 degrees N.	2 5	2 2	3 7	3 3	4 9	4 4	6 0	5 5
44 degrees N.	2 2	2 0	3 4	3 0	4 5	4 0	5 6	4 11
46 degrees N.	2 0	1 10	3 0	2 9	4 0	3 7	5 1	4 6
48 degrees N.	1 10	1 8	2 9	2 6	3 8	3 3	4 7	4 1

Latitude.	Distance from window line (at floor) to north end of pen.							
	12 feet.		14 feet.		16 feet.		18 feet.	
	Noon.	10 a. m. and 2 p. m.	Noon.	10 a. m. and 2 p. m.	Noon.	10 a. m. and 2 p. m.	Noon.	10 a. m. and 2 p. m.
	Height of window.							
	Ft. in.	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*
30 degrees N.	11 1	10 2	13 0	11 11	14 10	13 7	16 8	15 4
32 degrees N.	10 4	9 6	12 1	11 1	13 10	12 8	15 6	14 3
34 degrees N.	9 8	8 10	11 3	10 4	12 10	11 9	14 6	13 3
36 degrees N.	9 0	8 2	10 6	9 7	12 0	10 11	13 6	12 4
38 degrees N.	8 4	7 7	9 9	8 10	11 1	10 2	12 6	11 5
40 degrees N.	7 9	7 0	9 0	8 2	10 4	9 5	11 7	10 7
42 degrees N.	7 2	6 6	8 4	7 7	9 6	8 8	10 9	9 9
44 degrees N.	6 7	5 11	7 8	6 11	8 10	7 11	9 11	8 11
46 degrees N.	6 1	5 5	7 1	6 4	8 1	7 3	9 1	8 2
48 degrees N.	5 7	4 11	6 6	5 9	7 5	6 7	8 4	7 5

MARCH 1.

Latitude.	Distance from window line (at floor) to north end of pen.							
	4 feet.		6 feet.		8 feet.		10 feet.	
	Noon.	10 a. m. and 2 p. m.	Noon.	10 a. m. and 2 p. m.	Noon.	10 a. m. and 2 p. m.	Noon.	10 a. m. and 2 p. m.
	Height of window.							
	Ft. in.	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*
30 degrees N.	5 2	5 0	7 9	7 5	10 4	9 11	12 11	12 5
32 degrees N.	4 10	4 7	7 3	6 11	9 7	9 3	12 0	11 7
34 degrees N.	4 6	4 4	6 9	6 6	9 0	8 7	11 3	10 9
36 degrees N.	4 2	4 0	6 3	6 0	8 4	8 0	10 6	10 1
38 degrees N.	3 11	3 9	5 10	5 7	7 10	7 6	9 9	9 4
40 degrees N.	3 8	3 6	5 5	5 3	7 3	7 0	9 1	8 9
42 degrees N.	3 5	3 3	5 1	4 11	6 9	6 6	8 6	8 2
44 degrees N.	3 2	3 0	4 9	4 7	6 4	6 1	7 11	7 7
46 degrees N.	2 11	2 10	4 5	4 3	5 10	5 8	7 4	7 0
48 degrees N.	2 9	2 7	4 1	3 11	5 5	5 3	6 10	6 6

MARCH 1—Continued.

Latitude.	Distance from window line (at floor) to north end of pen.							
	12 feet.		14 feet.		16 feet.		18 feet.	
	Noon.	10 a. m. and 2 p. m.	Noon.	10 a. m. and 2 p. m.	Noon.	10 a. m. and 2 p. m.	Noon.	10 a. m. and 2 p. m.
	Height of window.							
	Ft. in.	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*
30 degrees N..........	15 6	14 11	18 1	17 4	20 8	19 10	23 3	22 4
32 degrees N..........	14 5	13 10	16 10	16 2	19 3	18 6	21 8	20 9
34 degrees N..........	13 5	12 11	15 8	15 1	17 11	17 3	20 2	19 5
36 degrees N..........	12 7	12 1	14 8	14 1	16 9	16 1	18 10	18 1
38 degrees N..........	11 8	11 3	13 8	13 1	15 7	15 0	17 7	16 10
40 degrees N..........	10 11	10 6	12 9	12 3	14 7	14 0	16 4	15 9
42 degrees N..........	10 2	9 9	11 10	11 5	13 7	13 0	15 3	14 8
44 degrees N..........	9 6	9 1	11 1	10 7	12 7	12 1	14 2	13 8
46 degrees N..........	8 10	8 5	10 3	9 10	11 9	11 3	13 3	12 8
48 degrees N..........	8 2	7 10	9 7	9 2	10 11	10 5	12 3	11 9

APRIL 1.

Latitude.	Distance from window line (at floor) to north end of pen.							
	4 feet.		6 feet.		8 feet.		10 feet.	
	Noon.	10 a. m. and 2 p. m.	Noon.	10 a. m. and 2 p. m.	Noon.	10 a. m. and 2 p. m.	Noon.	10 a. m. and 2 p. m.
	Height of window.							
	Ft. in.	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*
30 degrees N..........	8 4	8 7	12 6	12 11	16 8	17 3	20 10	21 7
32 degrees N..........	7 8	7 11	11 6	11 10	15 4	15 9	19 1	19 9
34 degrees N..........	7 0	7 3	10 7	10 10	14 1	14 6	17 7	18 1
36 degrees N..........	6 6	6 8	9 9	10 0	13 0	13 4	16 3	16 9
38 degrees N..........	6 0	6 2	9 0	9 3	12 0	12 4	15 0	15 6
40 degrees N..........	5 7	5 9	8 5	8 7	11 2	11 6	14 0	14 4
42 degrees N..........	5 2	5 4	7 9	8 0	10 5	10 8	13 0	13 4
44 degrees N..........	4 10	5 0	7 3	7 5	9 8	9 11	12 1	12 5
46 degrees N..........	4 6	4 7	6 9	6 11	9 0	9 3	11 3	11 6
48 degrees N..........	4 2	4 4	6 4	6 5	8 5	8 7	10 6	10 9

Latitude.	Distance from window line (at floor) to north end of pen.							
	12 feet.		14 feet.		16 feet.		18 feet.	
	Noon.	10 a. m. and 2 p. m.	Noon.	10 a. m. and 2 p. m.	Noon.	10 a. m. and 2 p. m.	Noon.	10 a. m. and 2 p. m.
	Height of window.							
	Ft. in.	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*
30 degrees N..........	25 0	25 10	29 2	30 2	33 5	34 6	37 7	38 9
32 degrees N..........	22 11	23 8	26 9	27 7	30 7	31 7	34 5	35 6
34 degrees N..........	21 1	21 9	24 8	25 4	28 2	29 0	31 8	32 7
36 degrees N..........	19 6	20 1	22 9	23 5	26 0	26 9	29 3	30 1
38 degrees N..........	18 1	18 7	21 1	21 8	24 1	24 9	27 1	27 10
40 degrees N..........	16 9	17 2	19 7	20 1	22 4	22 11	25 2	25 10
42 degrees N..........	15 7	16 0	18 2	18 8	20 9	21 4	23 4	24 0
44 degrees N..........	14 6	14 11	16 11	17 4	19 4	19 10	21 9	22 4
46 degrees N..........	13 6	13 10	15 9	16 2	18 0	18 6	20 3	20 9
48 degrees N..........	12 7	12 11	14 8	15 1	16 10	17 3	18 11	19 4

MAY 1.

Latitude.	Distance from window line (at floor) to north end of pen.							
	4 feet.		6 feet.		8 feet.		10 feet.	
	Noon.	10 a. m. and 2 p. m.	Noon.	10 a. m. and 2 p. m.	Noon.	10 a. m. and 2 p. m.	Noon.	10 a. m. and 2 p. m.
	Height of window.							
	Ft. in.	Ft. in.	Ft. in.	Ft. in.	Ft. in.	Ft. in.	Ft. in.	Ft. in.
30 degrees N	14 11	17 7	22 4	26 4	29 9	35 2	37 2	43 11
32 degrees N	13 0	15 1	19 7	22 8	26 1	30 8	32 7	37 9
34 degrees N	11 7	13 3	17 5	19 10	23 2	26 5	29 0	33 1
36 degrees N	10 5	11 9	15 7	17 7	20 10	23 6	26 0	29 4
38 degrees N	9 5	10 6	14 1	15 9	18 10	21 0	23 6	26 3
40 degrees N	8 7	9 6	12 10	14 3	17 1	19 0	21 5	23 9
42 degrees N	7 10	8 8	11 9	13 0	15 8	17 3	19 7	21 7
44 degrees N	7 2	7 11	10 10	11 10	14 5	15 10	18 0	19 9
46 degrees N	6 8	7 3	10 0	10 11	13 4	14 6	16 7	18 2
48 degrees N	6 2	6 8	9 3	10 1	12 4	13 5	15 5	16 9

Latitude.	Distance from window line (at floor) to north end of pen.							
	12 feet.		14 feet.		16 feet.		18 feet.	
	Noon.	10 a. m. and 2 p. m.	Noon.	10 a. m. and 2 p. m.	Noon.	10 a. m. and 2 p. m.	Noon.	10 a. m. and 2 p. m.
	Height of window.							
	Ft. in.	Ft. in.	Ft. in.	Ft. in.	Ft. in.	Ft. in.	Ft. in.	Ft. in.
30 degrees N	44 8	52 8	52 1	61 6	59 6	70 3	67 0	79 0
32 degrees N	39 1	45 4	45 7	52 11	52 2	60 5	58 8	68 0
34 degrees N	34 9	39 8	40 7	46 4	46 4	52 11	52 2	59 6
36 degrees N	31 2	35 2	36 5	41 1	41 7	46 11	46 9	52 10
38 degrees N	28 3	31 7	32 11	36 10	37 7	42 1	42 4	47 4
40 degrees N	25 8	28 6	30 0	33 3	34 3	38 0	38 6	42 9
42 degrees N	23 6	25 11	27 5	30 3	31 4	34 7	35 3	38 11
44 degrees N	21 7	23 9	25 3	27 8	28 10	31 8	32 5	35 7
46 degrees N	19 11	21 10	23 3	25 5	26 7	29 1	29 11	32 8
48 degrees N	18 5	20 1	21 6	23 6	24 7	26 10	27 8	30 2

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Bulletins in this list will be sent free, so long as the supply lasts, to any resident of the United States, on application to his **Senator, Representative, or Delegate in Congress**, or to the Secretary of Agriculture, Washington, D. C. *Because of the limited supply, applicants are urged to select only a few numbers, choosing those which are of special interest to them.* Residents of foreign countries should apply to the Superintendent of Documents, Government Printing Office, Washington, D. C., who has these bulletins for sale. Price 5 cents each to Canada, Cuba, and Mexico, 6 cents to other foreign countries. The bulletins entitled "Experiment Station Work" give briefly the results of experiments performed by the State experiment stations.

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34. Meats: Composition and Cooking.
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73. Experiment Station Work—IV.
77. The Liming of Soils.
78. Experiment Station Work—V.
79. Experiment Station Work—VI.
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144. Experiment Station Work—XIX.
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149. Experiment Station Work—XX.
150. Clearing New Land.
152. Scabies of Cattle.
154. Home Fruit Garden: Preparation and Care.
155. How Insects Affect Health in Rural Districts.
156. The Home Vineyard.
157. The Propagation of Plants.
158. How to Build Small Irrigation Ditches.
162. Experiment Station Work—XXI.
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166. Cheese Making on the Farm.
167. Cassava.
169. Experiment Station Work—XXII.
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174. Broom Corn.
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186. Experiment Station Work—XXIII.
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188. Weeds Used in Medicine.
190. Experiment Station Work—XXIV.
192. Barnyard Manure.
193. Experiment Station Work—XXV.
194. Alfalfa Seed.
195. Annual Flowering Plants.
196. Usefulness of the American Toad.
197. Importation of Game Birds and Eggs for Propagation.
198. Strawberries.
200. Turkeys.
201. Cream Separator on Western Farms.
202. Experiment Station Work—XXVI.
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204. The Cultivation of Mushrooms.
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222. Experiment Station Work—XXVIII.
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224. Canadian Field Peas.
225. Experiment Station Work—XXIX.
227. Experiment Station Work—XXX.
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239. The Corrosion of Fence Wire.
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246. Saccharine Sorghums for Forage.
248. The Lawn.
249. Cereal Breakfast Foods.
250. The Prevention of Stinking Smut of Wheat and Loose Smut of Oats.
251. Experiment Station Work—XXXIV
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Issued April 8, 1911.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 439.

ANTHRAX,

WITH SPECIAL REFERENCE TO ITS SUPPRESSION.

BY

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WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Animal Industry,
Washington, D. C., February 17, 1911.

Sir: I have the honor to transmit herewith a paper on "Anthrax, with Special Reference to its Suppression," by Dr. Henry J. Washburn, senior pathologist in the Pathological Division of this bureau. This paper was included in the Twenty-sixth Annual Report of the bureau, but in order to make it available for wider distribution in pamphlet form in response to requests for information about this disease, I respectfully recommend its publication also in the Farmers' Bulletin series.

Respectfully,

A. D. Melvin,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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ANTHRAX, WITH SPECIAL REFERENCE TO ITS SUPPRESSION.

NATURE AND HISTORY OF THE DISEASE.

Anthrax may be defined as an infection due to specific bacilli which may attack every species of domestic mammal, and for this reason may become one of the greatest scourges of animal life. Man is by no means immune, although, fortunately, the malady as it appears in the human subject is usually less acute than the form seen in cattle and sheep. This is probably due to the fact that the lesions in man occur most frequently from infection of the surface of the hands or feet, while cattle and sheep are more likely to swallow the infectious germs with their food, thus giving the germs immediate entrance into the animal system, where they can exert their most harmful influence without check or control.

Historians record an outbreak of anthrax in the south of Europe in 1613 which started with the cattle and spread from them to the populace, ultimately becoming a veritable scourge and causing the death of more than 60,000 people. From this it is very evident that the disease was far more virulent and far more inclined to attack all species of mammals during these earlier centuries than it is at the present day. It is even recorded that many deer and other varieties of game animals were destroyed during these early periods.

At the present time cattle and sheep are the chief sufferers, and the outbreaks appear to be limited to animals that run upon low, moist lands of a more or less mucky character. In certain regions of the country, where the land is mainly hilly, it has been found that pastures exist in which there are wet, low places, and that anthrax appears every season among the cattle of these farms if they are allowed to pasture upon these damp areas, but when good fences are built around them and the stock is kept upon the dry portions of the pasture the disease quickly disappears. Should the fence become broken down, allowing cattle to invade the infected area at certain seasons of the year, they are very likely to contract anthrax. In fact, certain plats of ground of this description have been found to retain the germs of anthrax for several years, a circumstance which has led many investigators to declare that the anthrax organism has the capability of growing from year to year without any artificial aid or cultivation, if only planted upon suitable soil; that it will sprout and grow, producing the plant and later the seed, thus providing a perpetual source of infection for the stock that may chance to be allowed to linger on this area of growing anthrax plants.

Because of the remarkable tenacity with which certain plots of ground retained their infection, Pasteur in 1880 reached the conclusion that the carcasses of animals dying from anthrax, even though deeply buried, retained their many infectious organisms and supplied them with such an amount of nutriment that they continued to multiply for years, and in this way produced an immense underground supply of virulent anthrax organisms. He decided further that these living infectious germs might be brought to the surface at any time through the agency of earthworms, and that, having reached the surface, they offered a very serious menace to any live stock that might wander into that vicinity. These suggestions were very generally accepted by the medical fraternity and for some years were taught as illustrative of the manner in which anthrax lurks in certain localities for years at a time; but later investigations by Kitasato have shown that spore formation by anthrax bacilli is very incomplete at a depth of 18 to 20 inches below the surface of the ground, and at even greater depths must be greatly suppressed by the presence of the products of decomposition. Koch has further stated that earthworms are incapable of taking up anthrax spores and bringing them to the surface.

Nevertheless, the fact remains that certain circumscribed areas of ground remain dangerous to stock from year to year. It is still an unsettled question whether the anthrax germs grow and multiply each season upon infected lands when conditions of moisture and warmth become favorable or whether the ground becomes infected at some certain time with bacilli, from which spores develop, which remain near the surface of the ground for years or until taken up by some susceptible animal.

Careful experiments have proven that anthrax bacilli flourish and retain their virulent properties in stagnant water for at least twelve months, and certain authorities claim to have observed them multiplying with no other nourishment than that afforded them by muddy water.

A look at some of the most seriously infected localities in this country will help us to understand the conditions which tend to perpetuate the infection. Upon the rice plantations of the South, where the fields are annually submerged to favor the starting of the rice plants, many of the animals used in the cultivation of the crops contract anthrax and die as a result if driven over the infected lands after the water has subsided and a few days of hot weather have intervened.

Where tanneries are located upon or near to streams there is great danger that anthrax will be brought to them upon hides and then be scattered over the low lands lying downstream from the point where the tanning process is carried on. This state of affairs exists especially near to those tanneries which work upon goat or sheep pelts from foreign countries. Infection in the form of spores adheres to these hides so persistently that ordinary fumigation fails to destroy it, and repeated outbreaks of the disease occur wherever such skins are unpacked and manufactured into leather. In making mention of this danger Professor Law writes:

> Since 1892 anthrax has prevailed along the banks of the Delaware River for a distance of 40 miles in New Jersey and Delaware, destroying from 70 to 80 per cent of the farm stock. The great morocco industry on this river draws infected hides from India, China, Russia, Africa, and South America, and the spores are carried and distributed by the hides.

Delafond studied the vitality of anthrax bacilli in 1860. He placed some blood from a sheep dead of anthrax in a glass container to which free access of air was granted. This was kept in a cool place at a temperature ranging variously from 45° to 60° F. (10° to 15° C.). When examined at the end of the fourth day it was found that the length of the filaments was increased, but that their diameter had remained unchanged. After eight to ten days their length was four or five times as great as when first brought under observation, thus proving that a veritable growth of the bacillus had taken place outside of the animal body and without the presence of animal heat.

In a letter from China to the London Lancet we read:

> The disease which has been destroying cattle throughout this district continues its ravages, though with diminished virulence, probably because there is now a scarcity of susceptible cattle. The mortality has varied from 50 to 75 per cent of the infected animals. To determine the extent of the disease I made inquiry as to the number of hides exported during the first three months of this year. They say that more than 260,000 left Peking, and that half a million would not be too high an estimate for the whole district. As no cattle are being slaughtered, this represents, approximately, the loss of cattle from the plague.
>
> The foreign firms that export hides, wool, bristles, and hair are in the hands of Chinese middlemen who roam about the interior buying here and there from the agricultural classes. I have been over some of the factories in Tientsin and have observed the steps they take to clean the stuff before its export. Bristles and hair are thoroughly well boiled in soda solution, wool is roughly carded and shaken free of as much dust as possible by machinery, and hides are sorted out and packed with naphthaline. The exporters claim that any further disinfection than is now given would spoil their goods and increase their expenses.
>
> The real difficulty does not lie with the *Bacillus anthracis* but with its spores, whose natural resistance is increased by their being embedded in the grease and dirt of the material while it is being dealt with in wholesale bulk in China. There can be little doubt that the passage home through the Indian Ocean and the Red Sea in the warm hold of a ship is all-conducive to their propagation and preservation, so that when the time comes for bristles and hair being

carded and separated out by workers at home these spores are liberated in an active condition, ready for human infection to a much greater extent than is the case in China.

Aside from the danger of direct infection to animals pasturing on infected areas, there exists the added danger of inoculation through the agency of hay or other crops that have been grown upon infected areas of land. The process of drying and curing the hay or forage does not lessen this danger, for drying favors the development of spores, and these, mingling with the dust and fragments of the dried forage, may be taken up by the wind and blown about, or may cause serious damage simply by being eaten by susceptible animals.

FORMS OF THE DISEASE.

The disease may appear in one of three forms—apoplectic, acute, or subacute.

The apoplectic form is most frequently seen attacking cattle or sheep at the beginning of an outbreak before the animals of the vicinity have developed any degree of natural immunity to the infection. Here the animals present symptoms of cerebral apoplexy. They reel and fall, bloody liquid flows from the body openings, and death soon follows. If the body is opened and search is made for evidence of disease, it may be quite impossible to detect any definite lesions or any change in the tissues.

The acute form of the disease develops more slowly, but becomes well established in twelve to twenty-four hours after the premonitory symptoms are noticed. In these cases the fever is intense (104° to 107° F.). The animal is greatly prostrated. Cerebral congestion causes excitement, which is followed by drowsiness and staggering gait. There is frequent passage of bloody urine, followed by convulsions and death. In this type of the disease, as well as in the apoplectic form, post-mortem examination of the carcass may fail to reveal any definite lesions.

The third form of anthrax, the subacute, is the most common. The symptoms are like those of the acute form except that they are of slower development. Instead of becoming established in twelve to twenty-four hours, one to seven days may be required. The fever is very high. Serious colics are often present. Local anthrax tumors appear externally, first near the shoulders, neck, and head, and are usually due to local injury or bruising, which gives rise to a collection of bacilli within the blood vessels of the part, whose resulting inflammation gives rise to the swellings or carbuncles. These tumors are at first hard and circumscribed, but later become cold, insensible, diffuse, and fluctuating. An examination of the carcass of an animal dead of anthrax of the subacute form will probably show many lesions or alterations. Hemorrhages may be found in almost all parts of the body. Serous infiltrations may be present beneath mucous membranes and skin. There will be swelling of the spleen, the liver, and the kidneys, and the blood will be of a muddy or tarry appearance and incoagulable. The cavities of the body contain more or less bloody effusion, and the lymphatic glands are swollen and contain small hemorrhages. The red blood cells have become broken down in large numbers and the serum of the blood has been markedly reddened. The walls of the intestines may appear perfectly normal, but hemorrhages are frequently seen, especially in the walls of the duodenum.

The subacute form is the one most commonly met, and it is the only form which responds favorably to treatment. Death ensues so quickly in the other two forms that attempts at treatment are of but little use.

Isolated or sporadic cases are usually of the subacute form, and are frequently limited to the formation of a tumor or carbuncle at the point of the body at which the infective germs first gained their entrance.

THE ANTHRAX BACILLUS.

The anthrax bacillus is a straight rod with ends slightly concave. It can not grow without the presence of air, but will grow in temperatures ranging from 55° to 106° F. It is not capable of motion. It measures 4 to 6 μ in length and about 1 μ in breadth. The bacilli multiply by fission, or dividing into two, or they may multiply much as corn does by the formation of seeds or spores, which sprout and produce a new anthrax plant when placed under suitable conditions. This simile may be carried further, for, like a tender blade of corn, the anthrax plant or bacillus may be destroyed very easily by the application of heat or cold, but the seed or spore will resist considerable heat and is unaffected by freezing, still retaining its virulence in spite of being subjected to either temperature.

When cultivated artificially and grown in the laboratory, a luxuriant growth may be obtained by planting upon any of the culture media commonly used for bacterial growth. The organisms grow rapidly and produce dense, thick clumps on potato, gelatin, agar, or other solid material. They grow with equal readiness in fluid media such as beef broth, milk, etc., but will not produce spores while growing in media of this character, as spores can not develop except in the presence of free air or oxygen.

METHODS OF COMBATING INFECTIOUS DISEASES.

Whenever attempts are made to control or suppress an infectious disease a thorough study of its character must be made, as the measures to be applied will very largely depend upon the results of such investigation. Take foot-and-mouth disease, for instance. This has become so firmly established in the flocks and herds of certain European countries, especially in the southeastern portion, that it is considered almost an endemic, and while the stock owners are constantly trying to suppress the disease, they never go at it with the fixed purpose of obtaining its complete eradication. But in this country the circumstances are very different. Here the outbreaks have only occurred after long intervals, and in every instance, save one, have been traceable to some definite source. The number of animals attacked in each outbreak has been comparatively small. Hence, in view of the rapid transmission of the infection, not alone by sick animals, but by men, dogs, or chickens that may chance to come in contact with infected cattle or stables, any dallying, experimental measures must not be considered for a moment; and, taking this view of the matter, the immediate slaughter of all infected and exposed susceptible animals has been insisted upon each time that the disease has appeared within the borders of this country.

How very different is the method of dealing with Texas fever. But these differences of treatment are only such as are demanded by the differences in the characters of the two infections. Texas fever is known to be dependent for its origin upon the bite of an infected cattle tick, by means of which the minute parasite which destroys the blood cells of its victims gains entrance to the circulatory system, and multiplying rapidly breaks down so many blood corpuscles that fatal fever quickly results. To obviate this disease, all that is necessary is to keep the cattle free from contact with infectious ticks or to immunize them by the careful application of blood or ticks under proper precautions. Present endeavors of the Bureau of Animal Industry toward the suppression of Texas fever are being extended along these very lines. By establishing and maintaining the Texas fever quarantine line, it is preventing southern cattle from bringing dangerous ticks into northern pastures where their presence would quickly act as a scourge. The Bureau is also doing an immense amount of work in removing all infectious ticks from certain regions of the South, not with a view to saving the cattle of these regions from death from Texas fever, because they have become immune to that disease, but for the purpose of making these cattle more valuable than they are at present, as they may be given free bills of health for shipment to northern points and northern markets just as soon as it can be shown that they originate in tick-free districts.

There are a number of serious contagious diseases which terminate fatally in almost every case of attack. For these no treatment is attempted, but preventive measures may be applied with the greatest assurance that further spread may be stopped. Such is rabies. Once the disease develops, no known treatment will avail to save the patient's life; but if inoculative treatment is applied soon after the victim is bitten by the rabid dog the chances for recovery are excellent.

In studies of the various infectious diseases it has been found that one of the most desirable means of preventing their extension is to furnish the susceptible and exposed animals with artificial immunity. This is the case with tuberculosis, blackleg, anthrax, rabies, hog cholera, Texas fever, and the like. Many animals prove to be naturally immune to these diseases, while others must be made immune by inoculation with suitably prepared materials before they are able successfully to withstand attacks from the specific organisms which cause the several maladies.

Educated investigators the world over have expended a vast amount of effort and study in attempts to discover and perfect the most effective and at the same time the most practicable means of immunizing animals against the more destructive of the infectious diseases. Immense amounts of money have been appropriated for the advancement of these researches, both from governmental sources and from gifts of private wealth. The goal sought by these searchers along lines of agricultural interest is the discovery of some means by which immunity may be conveyed to a large number of animals readily and at slight expense.

VACCINATION AS A PREVENTIVE.

Satisfactory immunity is readily granted to cattle at the present time against the ravages of blackleg or symptomatic anthrax, through the injection beneath the skin of the susceptible animal of some material containing the living but weakened germ of the disease. The amount of this material is so graduated that it causes the prompt development of the very disease that is being guarded against, but only in a mild and comparatively harmless degree. There is considerable elevation of temperature, and there may even be limited tumor formation, but only in the rarest cases does this type of blackleg, that has been intentionally produced by inoculation, progress so far that the animal is seriously injured. The value of artificially produced immunity in the struggle against this disease is shown by the fact that the losses of young cattle which reached from 15 to 20 per cent in certain infected localities previous to the discovery of vaccine treatment, have been reduced to one-half of 1 per cent at the present time where vaccines are used.

It is at once apparent that hard and fast conclusions can not be drawn favoring vaccination against anthrax from results obtained in the suppression of blackleg by the use of blackleg vaccine. But there are a sufficient number of points of similarity between the two diseases to justify considering the two together. They are so similar that for many years no distinction was made between the two maladies, but all cases were called anthrax.

The successful vaccination of cattle against either of these two troubles must consist in giving the animal that is to be safeguarded a sufficiently severe attack of the disease that is feared to provide the body tissues with such a degree of resistance that no germs can be taken into the system in fatal numbers and remain to find lodgment and nurture there. After such vaccination the animal is safely protected and can go with perfect safety into fields that would have proven deadly before the vaccination was performed.

Just how this immunity is obtained is still an open question, but it is very manifest that the attenuated organism is able by its growth to affect the tissues (some say the animal cells, others the fluid tissues) in such a manner that virulent organisms of the variety presented in the vaccine can not possibly thrive, and without the rapid multiplication of virulent organisms within the animal tissues there can be no disease.

Blackleg vaccine is prepared from the affected muscle of an animal dead of that disease. Anthrax vaccine is produced by the cultivation in beef broth of pure cultures of anthrax bacilli, hence may be manufactured in unlimited quantities without having recourse to any animal suffering from the disease.

Starting with a thrifty culture of anthrax bacilli growing in a flask of bouillon, Pasteur, in 1881, by a series of experiments found that subjecting it to a temperature of 108.5° F. for twelve days would so lower the virulence of the organisms that they would only exceptionally cause death when injected into rabbits. Continuing the attenuation by subjecting the bacilli to the same degree of heat for twelve days longer, or twenty-four days in all, he discovered that he had in his possession a living culture of anthrax bacilli that had lost its power for killing cattle, sheep, rabbits, or guinea pigs, although still capable of killing white mice. This was the beginning of the practical preparation of anthrax vaccine, for he soon found that cattle or sheep when inoculated with the culture of twenty-four days' attenuation would survive the treatment and would gain a very material power in resisting infection from inoculations with bacilli of a high degree of virulence. This power of resistance is needed to enable them to withstand the injection of the second and stronger vaccine, which, having been subjected to attenuating heat for only twelve days, is possessed of considerable virulence.

In his early investigations he made experiments upon a flock of 50 sheep. Half of these were vaccinated with his attenuated culture of anthrax bacilli. Twelve days later they received an inoculation with stronger vaccine, and forty days after this the whole flock was inoculated with a virulent anthrax culture. Two days later the vaccinated animals were all sound, while the checks were all dead.

Following this striking demonstration by Pasteur, 60,000 sheep and 6,000 cattle were at once treated in France. The following year the same form of treatment was applied to 270,000 sheep and to 55,000 cattle. Since that time this method of vaccinating against anthrax has found very general application in France whenever losses have occurred, making it evident that certain fields or pastures have become infected with anthrax bacilli. As a result, Nocard and Leclainche state that anthrax has disappeared from many sections in which it formerly decimated the live stock and that the medical doctors at the same time reported a disappearance of malignant pustules from among their human patients.

Soon after this method of immunization by the use of attenuated cultures had become suitably tested and perfected in France, steps were taken to supply vaccinating material to other countries, and reports of its successful application were soon received from Russia, South America, Australia, and other lands.

Other investigators, fearing to use the living anthrax bacillus, even though greatly attenuated, have turned their attention to the production of a serum that should possess immunizing powers equal to those of the attenuated organism. The immunity granted by serum inoculations becomes effective very quickly, but does not last long unless reinforced by the addition of virulent material at about the time that the serum is injected. At first the virulent material was injected a few days after the serum had been applied, but the latest recommendations are that they should be given simultaneously; wherefore it is now customary to inject immunizing serum into one side of the animal's neck and virulent serum into the other side before releasing it.

Very interesting facts have been disclosed through the efforts of various investigators to perfect sera for immunizing in outbreaks of anthrax. It is well known that a very small amount of virulent blood will serve to convey the disease from an anthrax carcass to a healthy animal. A fly can easily carry enough on his proboscis to kill a horse. It may safely be admitted that a single drop is sufficient to cause the death of a horse; yet Sobernheim has, by means of repeated injections, using cultures gradually increasing in virulence, produced such a high degree of immunity in a horse that it withstood the injection into its veins of 500 c. c. (about 17 fluid ounces, or more than a pint) of the most virulent anthrax culture obtainable. This is a good illustration of the word "immunity." It is something that this horse in question has received into his system through the several inoculations of sera that enables him to receive unharmed an injection of living anthrax fully ten thousand times as large as the amount that would have sufficed to kill him previous to his immunization.

Another peculiarity discovered by investigators along these lines is that a culture of anthrax bacilli that has once been attenuated can then be cultivated indefinitely without necessarily causing any alteration in the degree of its virulence. If we let 100 represent the virulence of an active, fresh culture, and 10 the degrees of virulence in one that has been greatly attenuated, it has been repeatedly shown that one can cultivate the attenuated germs for many generations without causing any observable alteration from this virulence rating of 10; yet it only requires the single passage of this material through a white mouse to restore its virulence at once to approximately 100.

In this country the Delta lands of the Mississippi Valley are most thoroughly permeated with anthrax infection. The losses through anthrax have there been enormous, due in great measure to the large number of valuable mules owned and worked upon the sugar plantations. Dr. W. H. Dalrymple has for years been engaged in fighting this plague in Louisiana, and he reports as follows on the results of preventive inoculation:

> Perhaps the most convincing evidence of the beneficial effect of this method of prevention in Louisiana is the fact that those localities which suffered most from yearly, or at least periodic, epizootics of anthrax, before vaccination became so generally adopted, have experienced the past summer a wonderful degree of immunity from the disease which, I think, we must attribute to the fact that the use of the lymph is now almost general in these sections and that greater attention is being directed to the more careful disposal of the dead animal, our people more fully appreciating its being the chief source from which this most deadly disease is spread.
>
> I believe we are gradually solving the anthrax problem in the Pelican State, and the progress we have already made is, I think, considerable and fairly satisfactory when we take into account the erroneous and visionary ideas which prevailed up to ten or twelve years ago regarding the true nature of the disease and the most potent factors in causing its spread.
>
> I question very much if ten years ago a single dose of preventive vaccine was used or an anthrax carcass destroyed as a sanitary precaution against the spread of the disease in our State. To-day there are probably 40,000 or 50,000 doses of vaccine used, and carcasses are being much more carefully looked after, which I feel indicates some progress at least.

The material which Doctor Dalrymple used so successfully and which called forth the above encouraging report was manufactured in accordance with Pasteur's findings and consisted of a double inoculation with attenuated anthrax cultures.

In carrying out tests for the determination of the reliability of attenuated living cultures the Bureau of Animal Industry has succeeded in immunizing test animals to such a perfect degree that they were able to withstand subcutaneous injections of extremely virulent anthrax cultures. Cattle, sheep, goats, burros, and a mule were subjected to these fortifying inoculations, and were later proven to be immune to anthrax. The first injection caused but slight disturbance of the health of any animal, and only slight elevation of temperature. The second injection resulted in somewhat higher temperatures, and in a few cases in transient indifference to feed. The final test of their immunity was made with a pure culture of anthrax bacilli of the highest degree of virulence obtainable. The application of this severe test soon resulted in very high temperatures and in rather general refusal of feed for a day or two; but this test far exceeded in severity any chance for infection that the animals could have incurred by pasturing over infected lands. Pure anthrax bacilli were forced into the tissues in great numbers, and the ultimate survival and full recovery of the animals after this severe treatment offers the best possible argument in favor of preventive inoculation in all cases in which animals are positively known to be exposed to contact with anthrax bacilli in infected stables or pastures.

The material used in vaccinating against anthrax has many dangerous properties, since it contains living anthrax organisms; hence it should never be used except in regions in which the disease has already appeared, and it should be used only by qualified veterinarians, as careless handling might result in the serious extension of the very disease that it was desired to eradicate. Vaccines for this work should be obtained from reliable manufacturers, as the use of weakened or diluted material can only lead to disappointing results.

The season of the year in which the vaccination is undertaken makes considerable difference in results, for it has been shown that there is a natural tendency toward the suppression of the disease in the infected plats of ground during the winter months.

OTHER PREVENTIVE MEASURES.

In future attempts to eradicate anthrax from infected districts preventive inoculation will undoubtedly play a very important part. But there are many other steps which should be taken into consideration in addition to the vaccination. Infected areas should be thoroughly drained and kept under cultivation for some time before attempts are made to pasture stock upon them. Sunlight greatly hinders the development of anthrax bacilli, and the repeated stirring of the soil favors the action of the sun's rays.

The complete destruction of all anthrax carcasses is also a very important matter. This is best accomplished by burning, but as this method of disposal is impractical in many localities, deep burial may be practiced instead. Covering the carcasses within their graves with quicklime adds another valuable precaution against further dissemination of the infection. No animal dying from anthrax should ever be skinned or cut open, as the blood from such sources is one of the most dangerous means of spreading the infection, being charged while in the animal with great numbers of bacilli, which quickly turn into spores as soon as spread about upon the surface of the ground. All discharges from the body openings should also be burned or buried deeply, as these are frequently of a virulent character.

One of the most common obstacles to sanitary police control of outbreaks of anthrax is the opposition of the owners of the affected animals to any regulation which requires them to dispose in a safe and satisfactory manner the cadavers of animals dying from the disease. Many localities have failed to secure legal enactments demanding suitable destruction of infectious carcasses, and others which have laws upon their statute books have an opposing public opinion that largely nullifies the real intent and purpose of the law, with the result that carcasses filled with deadly material are allowed to lie about in the fields to be scattered by prowling dogs or birds; or they may be dragged to the nearest stream and thrown into the water, only to be floated along bearing their infection to neighboring properties. A little practical application of the golden rule by interested stockmen would, under these circumstances, not only prove beneficial to their neighbors, but the benefits would be felt upon their own properties in later seasons. It is imperative that all carcasses of animals dying from anthrax should be safely burned or buried if the eradication of the infection is ever to be reached.

There are some encouraging features to be noted in connection with outbreaks of anthrax. One of these is the limitation of the infection to certain restricted areas. Another is that the disease does not sweep across a whole State in a few days, as foot-and-mouth disease is inclined to do. A third is that drainage of the infected parcels of ground usually removes the danger. So let those who have suffered losses of stock from anthrax take courage and resolve to ward it off in the future by fencing, draining, and plowing infected plats, by burning or burying deeply all infected carcasses, and by the vaccination of the healthy animals that are unavoidably exposed. Such methods will lessen the losses and cause the gradual disappearance of the plague.

[A list giving the titles of all Farmers' Bulletins available for distribution will be sent free upon application to a Member of Congress or the Secretary of Agriculture.]

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Issued March 27, 1911.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 440.

SPRAYING PEACHES FOR THE CONTROL OF BROWN-ROT, SCAB, AND CURCULIO.

BY

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OF THE BUREAU OF PLANT INDUSTRY,

AND

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OF THE BUREAU OF ENTOMOLOGY.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Washington, D. C., February 18, 1911.

Sir: We have the honor to transmit herewith, and to recommend for publication as a Farmers' Bulletin, a manuscript entitled "Spraying Peaches for the Control of Brown-Rot, Scab, and Curculio," by W. M. Scott, of the Bureau of Plant Industry, and A. L. Quaintance, of the Bureau of Entomology.

The loss to the peach growers of the United States from brown-rot, scab, and curculio amounts to millions of dollars annually, and until recently there has been no effective means of preventing this great shrinkage. Experiments conducted by this department during the past four years, however, have abundantly demonstrated that these troubles can be thoroughly controlled at a small cost. The results of experiments and demonstrations conducted during 1910 and instructions for the application of the treatment are contained in the accompanying manuscript.

Respectfully,

Wm. A. Taylor,
Acting Chief, Bureau of Plant Industry.
L. O. Howard,
Chief, Bureau of Entomology.

Hon. James Wilson,
Secretary of Agriculture.

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SPRAYING PEACHES FOR THE CONTROL OF BROWN-ROT, SCAB, AND CURCULIO.

INTRODUCTION.

The peach-growing industry in the United States at the present time has become a very important one, being second in extent among fruits only to the cultivation of the apple. According to the 1900 census there were in the territory east of the Rocky Mountains, which is subject to the troubles treated in this bulletin, approximately 91,000,000 bearing peach trees. Since that time the number of bearing trees has increased by perhaps one-fourth, making a possible total of 113,750,000 trees. Careful estimates indicate that the quantity of fruit annually harvested by peach growers in this territory is not less than 10,000,000 bushels. Thus the crop for 1910, although an unusually large one, was for the territory mentioned, probably not less than 12,000 000 bushels, with a gross valuation of about $12,000,000 to $16,000,000.

Although many insects and parasitic fungi occur on the peach, comparatively few are of much economic importance. Of the diseases of the peach, the brown-rot (*Sclerotinia fructigena* (Pers.) Schröt.) and scab, or black-spot (*Cladosporium carpophilum* Thüm.), are responsible for practically all of the damage to the fruit crop and the insect injury is limited almost entirely to the attack of one species, the plum curculio (*Conotrachelus nenuphar* Herbst.).

The brown-rot probably causes more loss to peach growers than all other maladies of the peach combined, with perhaps the exception of "yellows," which kills the trees outright. In the South the brown-rot often causes the destruction of half or even practically all of the crop, and throughout the territory under consideration the annual shrinkage in yield is perhaps 25 to 35 per cent of the crop, representing a valuation of about $3,000,000 to $4,000,000. Although the brown-rot is always present in the peach orchards of humid sections, causing a rotting of a certain proportion of the fruit, it becomes notably destructive only under certain weather conditions, when within a period of 10 days or two weeks it will spread so rapidly as to result in the destruction of practically the entire crop. Such disastrous outbreaks are likely to occur during moist, humid weather as the fruit begins to ripen. The brilliant prospects of the orchardists are thus within a few days obliterated as if by fire.

The peach scab is the only other destructive disease of the fruit in the eastern United States, and, while it does not occur in such sudden and disastrous outbreaks, the sum total of the injuries caused by it are very important, resulting in a shrinkage in crop values of perhaps $1,000,000 annually. This disease occurs all over humid America where the peach is grown and is especially troublesome east of the Allegheny Mountains. It not only renders much of the fruit unfit for market, but so mars the appearance of the marketed fruit as to reduce its value.

The plum curculio is of scarcely less importance in its relation to the successful production of the peach than the diseases above mentioned. By its punctures of the fruit in feeding and egg laying and the injury resulting from the larvæ, or grubs, within the fruit it brings about a reduction in yield of a valuation amounting to perhaps not less than $3,750,000 annually. The puncturing of the fruit also greatly favors the brown-rot, and curculio control is a prime essential in preventing losses from this malady. Although the plum curculio is very generally distributed eastward of the Rocky Mountains, it is especially abundant in the Middle and Southern States. During years of full fruit crops its injuries are less important, simply more or less thinning the fruit; but when the crop is light little fruit may escape its ravages.

The troubles mentioned have more than kept pace with the development of the peach-growing industry, and the cultivation of this crop, especially in the South, has become more and more hazardous. Practical means for their control have, therefore, been most urgently needed, and much attention has been given by investigators of the Department of Agriculture and of the various agricultural experiment stations to supply this want. While it has been possible by the use of certain sprays, such as Bordeaux mixture and Paris green, to effectively reduce these troubles, the sensitiveness of the foliage and fruit of the peach has practically prevented their employment, and the peach grower has been almost helpless against them. A spray effective in the control of these troubles and which at the same time may be used with perfect safety on the trees and fruit has been the most important requirement to place the industry on a reasonably secure foundation.

Experiments begun by the Bureau of Plant Industry some three or four years ago and carried out under varying climatic and other conditions in different parts of the eastern United States have established beyond question the effectiveness of the self-boiled lime-sulphur wash for the control of the fungous troubles mentioned. Earlier experiments by the Bureau of Entomology had already shown that by the proper use of arsenate of lead the curculio could be largely controlled, though on account of danger of foliage injury its use had not been unqualifiedly recommended. Cooperative experiments between the two bureaus have shown that the fungicide and arsenical may be used as a combined spray with satisfactory results in controlling these troubles and without injury to the fruit and foliage of the peach. Hence, there is now available a satisfactory method for the control of these three serious obstacles to successful peach culture.

In the following pages the brown-rot, peach scab, and curculio are treated with reference to their occurrence on the peach, and results are given of experiments and demonstrations in their control conducted jointly by the Bureau of Plant Industry and the Bureau of Entomology during 1910. The writers were assisted in this work by E. L. Jenne and E. W. Scott, of the Bureau of Entomology, and by Leslie Pierce and G. W. Keitt, of the Bureau of Plant Industry.

BROWN-ROT.

NATURE AND CAUSE OF THE DISEASE.

Brown-rot is a fungous disease which affects the stone fruits, such as the peach, plum, and cherry, and to a less extent some of the pome fruits, such as the apple, pear, and quince, producing a so-called rot of the fruit and blight of the twigs. It is caused by a fungus known to botanists as *Sclerotinia fructigena* (Pers.) Schröt. Brown-rot is the common name usually applied to the disease, but monilia, the generic name of the imperfect stage of the fungus, is often used by some of the older fruit growers.

The disease appears on the fruit as a small circular brown spot, which under moist, warm conditions enlarges rapidly, soon involving the entire fruit in decay (fig. 1). The spots do not usually become sunken, and the fruit remains plump until almost entirely decayed. The fungus growing in the tissues of the fruit breaks through the skin, forming small, grayish tufts of spore-bearing threads. These tufts, although few on young spots, soon become so numerous as to give the diseased area a grayish, moldy appearance, which is responsible for the term "peach mold" sometimes applied to the disease. The spores which are produced in great abundance by these fungous tufts are blown by the wind and carried by insects and birds from fruit to fruit, tree to tree, and orchard to orchard. Finding lodgment on the fruit under favorable conditions of temperature and moisture, these spores germinate, producing a fungous growth, which ramifies and kills the tissues. These dead tissues turn brown, and the fungus breaks through the surface, producing another crop of spores. The process is very rapid, only a few days intervening between one generation of spores and another.

DAMAGE TO THE PEACH.

Although the young fruits soon after the petals are shed may become affected, as a rule no marked outbreak occurs until the fruit is half grown or larger, and the greatest destruction is wrought at harvest time. The fruit crop may reach maturity in perfect condition and yet be destroyed before it can be picked. Moreover, the fruit may become affected in transit or after reaching the market. It is no uncommon experience among peach growers to have a carload of peaches leave the orchard in apparently good condition and arrive on the market specked and practically worthless, owing to the brown-rot fungus. Through handling by pickers and packers some fruit in every package may become contaminated with spores from a few diseased fruits in the orchard. Enough moisture usually develops in the car to germinate the spores, and if the refrigeration is poor the fruit is likely to go down in partial or total decay before reaching the consumer.

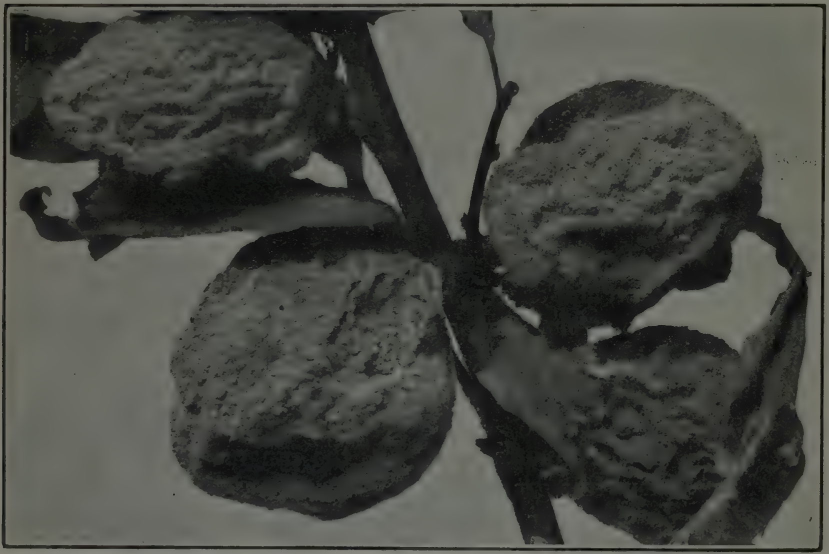

FIG. 1.—Peaches entirely destroyed by brown-rot, showing gray masses of spores of the fungus.

The fungus also attacks the blossoms and extends from these into the fruit-bearing twigs, often girdling them. In a wet spring the fruit crop may thus be materially reduced, although this form of attack is only occasionally serious. In like manner the fungus may extend from diseased fruits into the twigs. Following an outbreak of brown-rot on the fruit, these twig infections may become so severe as to give the trees a blighted appearance.

WINTER STAGE AND SOURCE OF INFECTION.

The affected fruits largely drop to the ground, although many of them hang on the trees for months. They become dried and shriveled, and at this stage are known as brown-rot mummies. The fungus passes the winter in these mummies, which form the chief source of infection for the new fruit crop. When moistened by spring rains, the mummified fruits on the trees and on the ground become covered with fruiting tufts of the fungus, producing countless numbers of spores.

After 18 months, or at the end of the second winter, about the time peach trees are in bloom, there arise from the mummies on the ground, partly or entirely covered with soil, fruiting bodies representing the perfect stage of the fungus. These are dark-brown somewhat bell-shaped disks, resembling toadstools. In them are produced an abundance of ascospores, which rise in the air and are wafted by the wind. These, as well as the summer spores (conidia), serve to infect the blossoms and young fruits. The propagation of the fungus being thus so abundantly provided for, it is not surprising that a crop of fruit may be destroyed without much warning.

INFLUENCE OF THE WEATHER AND INSECTS.

In sections where the brown-rot is prevalent the spores are practically omnipresent, and only favorable conditions for their germination and the rapid growth of the fungus are required to start an outbreak of the disease. The most important factor is excessive moisture in the form of rain, which not only favors the production and germination of the spores and the growth of the fungus, but renders the fruit soft and watery, and therefore more susceptible to the disease. High temperatures also favor the disease, although the fungus grows readily in mild summer temperatures. Prolonged cloudy weather with frequent light showers is more dangerous than a hard rain followed by clearing. Warm, muggy weather, when the fruit is maturing, is often disastrous to the crop.

Insects, especially the curculio and certain plant bugs, play an important part in the distribution of the spores and the infection of the fruit. Although the fungus under favorable conditions is apparently able to pass readily through the unbroken skin of the fruit, it is greatly aided by insect abrasions. In the process of feeding and egg laying, the curculio punctures the skin of the fruit, opening the way for the fungus and in many cases perhaps actually inserting the spores. This insect may render spraying for brown-rot partially ineffective by breaking the sprayed skin of the fruit, thus exposing the flesh to attack. In the treatment of the disease it is, therefore, important to combine an insecticide with the fungicide so as to destroy the beetles.

TREATMENT.

Experiments conducted by the Bureau of Plant Industry during the past four years have shown conclusively that this disease can be controlled by the use of self-boiled lime-sulphur mixture.[1]

A schedule of applications for the combined treatment of brown-rot, scab, and curculio is given on pages 38–40 of this bulletin.

PEACH SCAB.

ECONOMIC IMPORTANCE OF THE DISEASE.

Of the diseases affecting the fruit of the peach, scab is second only to brown-rot in economic importance; in fact, it is more destructive than brown-rot in some of the mountain districts. It dwarfs the fruit and causes premature dropping, thereby reducing the yield; it ruptures the skin, opening the way for brown-rot attacks; and it mars the appearance of the fruit, thus lowering the grade and reducing its market value. The disease is common wherever peaches are grown east of the Rocky Mountains, scarcely an orchard being entirely free from it. In some cases, especially in a dry season, only a small percentage of the fruit may become affected and with only a few small harmless spots, while in other cases the entire crop may become so badly affected as to be unmarketable. If the loss in the orchard

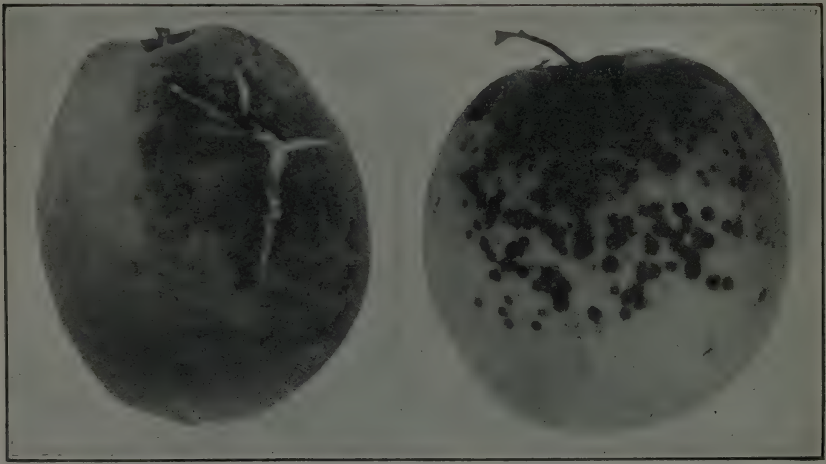

FIG. 2.—Peach scab on Elberta peaches, showing spots and cracks caused by the disease.

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[1] Circulars 1 and 27 and Bulletin 174, Bureau of Plant Industry, U. S. Dept. of Agriculture.

and the reduction in market value are both considered, it seems evident that a loss of 10 per cent of the total value of the peach crop in the eastern United States is caused by peach scab.

THE NATURE AND CAUSE OF THE DISEASE.

The name commonly applied to this disease is "peach scab," but it is also known as "black spot" and "freckles" and in some districts it is often improperly called "mildew." It is caused by the fungus *Cladosporium carpophilum* Thüm., which grows in the skin of the fruit, producing small, circular dark-brown spots. When numerous, these spots give the fruit a smutty or blackened appearance and cause the skin to crack (fig. 2). Fruit badly affected does not reach normal size and often drops prematurely.

The fungus also attacks the twigs, producing brown spots, in which it passes the winter. These spots are very common in peach orchards, but they apparently do little damage to the twigs. During the spring or early summer the fungus growing in the spots produces olive-brown spores which serve to infect the young peaches. Similar spores are also produced on the fruit spots.

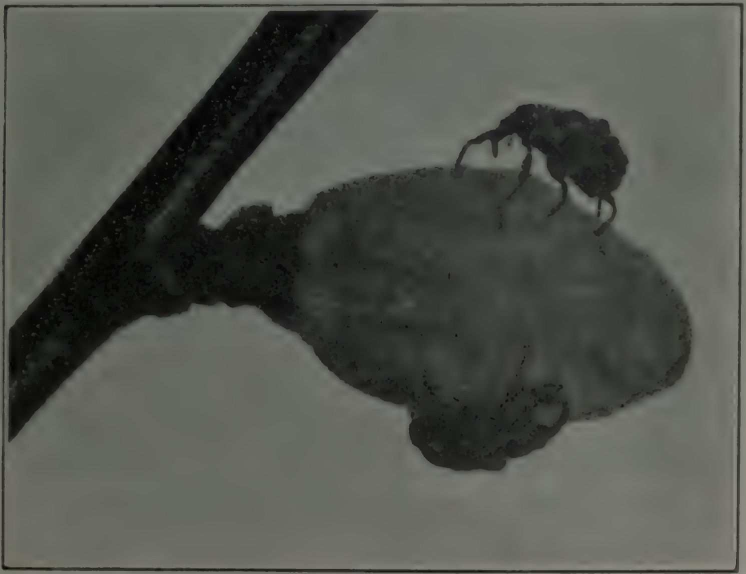

FIG. 3.—Two adult curculios on a young peach. (Considerably enlarged.)

THE SUSCEPTIBILITY OF VARIETIES.

There is a considerable difference in varieties as to their susceptibility to peach scab. In general, the late varieties are much more susceptible than the early varieties. This is due, in part at least, to the fact that the fruit of the late-maturing varieties is exposed to infection over a longer period and the opportunity for the development of the disease is greater. Of the commercial varieties, the Heath is perhaps the most susceptible; in fact, the disease has almost prohibited the growing of this variety except in a small way. The Bilyeu variety is also badly affected and the disease has restricted its culture to high, well-drained locations. The Salway, Smock, and most of the other varieties that ripen after the Elberta usually suffer rather severely from this disease, while the Elberta may be considered somewhat less affected, although the crop of this variety often becomes badly diseased. The varieties that ripen earlier than Elberta are as a rule only slightly or moderately affected. This is especially true of the Carman, Hiley, Champion, and Belle. On the other hand, the Mountain Rose and Early Rivers are quite susceptible to the disease.

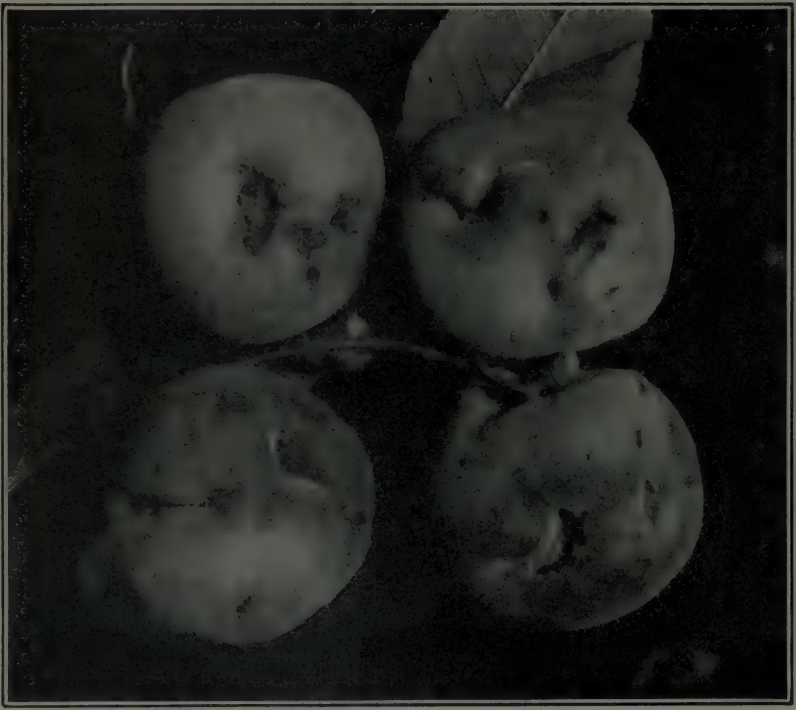

FIG. 4.—Deformed ripe peaches resulting from feeding and egg-laying punctures.

TREATMENT.

The development of the self-boiled lime-sulphur mixture as a fungicide has made possible the control of the scab without injury to the fruit or foliage. The injury produced by this disease may be almost entirely prevented at a small cost. This has been abundantly demonstrated through experiments conducted by the Bureau of Plant Industry during the past three or four years.[1] The schedule of applications for the control of this disease, together with the brown-rot and curculio, is given on pages 38–40 of this bulletin.

THE PLUM CURCULIO.

WHAT THE CURCULIO IS.

The curculio is a small snout beetle of the family Curculionidæ, which contains many species of economic importance. The adult insects vary somewhat in size, but will average about three-sixteenths of an inch in length. Figure 3 illustrates two beetles on a newly set peach, all considerably enlarged. In the course of its growth the insect passes through four stages, namely, the egg, larva, pupa, and adult. The larva, or grub, is the small whitish worm frequently found in ripe peaches, plums, and cherries and is well known to lovers of these fruits.

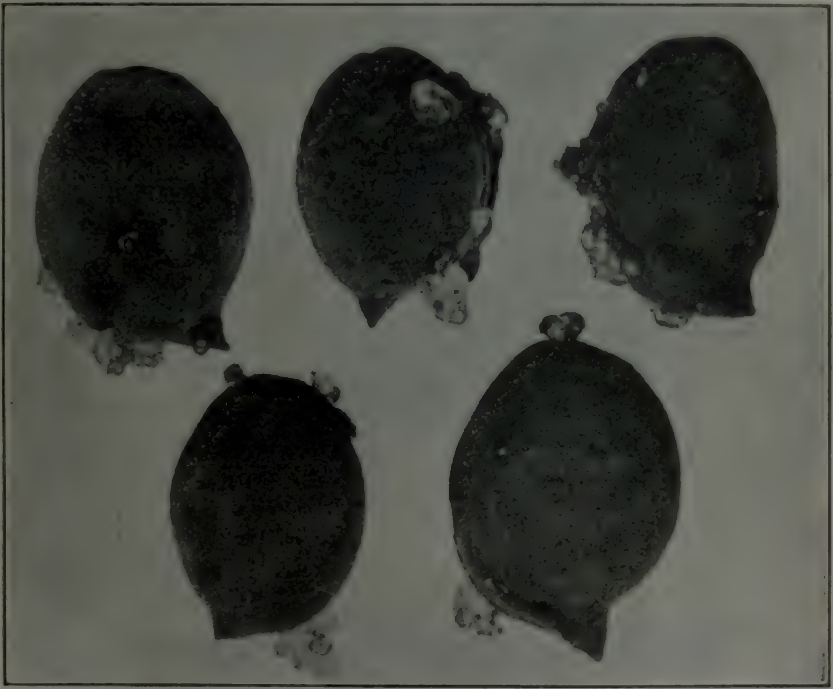

FIG. 5.—Peaches showing the exudation of gum from curculio punctures.

There are many common names for this insect, such as the "plum curculio," "plum weevil," "peach curculio," "peach worm," "fruit weevil," "little Turk," "curculio," etc. The name here used, however, is perhaps best fixed in literature on economic entomology and has been adopted for this species by the American Association of Economic Entomologists.

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[1] Circulars 1 and 27 and Bulletin 174, Bureau of Plant Industry, U. S. Dept. of Agriculture.

The plum curculio is a native American insect and fed originally, as it feeds at the present time, on wild plums and other wild fruits, especially Crataegus. Its injuries were noted as long ago as 1736, and it was the subject of an extended article published in 1804. Our early horticultural literature abounds with references to its depredations, especially to plums, which were apparently grown with the greatest difficulty.

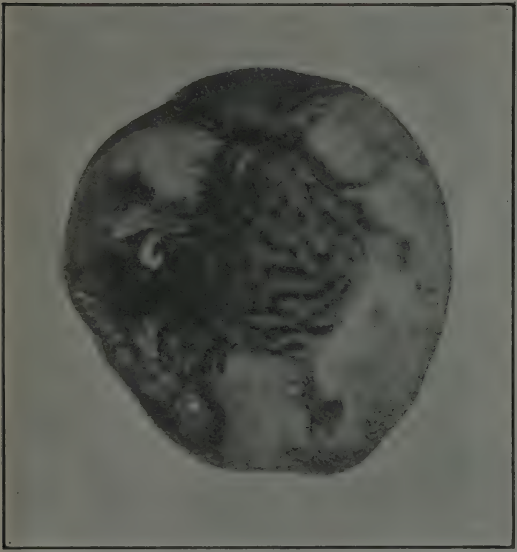

FIG. 6.—Peach infested with curculio larva, or grub.

So far as is known, the plum curculio is still confined to North America, ranging from southern Canada south to Florida and Texas and west to about the one hundredth meridian. It appears to be restricted in its westward spread by the more arid climate of the Great Plains region. It is probably present throughout its entire area of distribution, but is especially abundant in the Central and Southern States.

FOOD PLANTS AND CHARACTER OF INJURY.

Practically all stone and pome fruits, such as peaches, plums, apricots, nectarines, cherries, apples, pears, etc., are used by the curculio for feeding and egg-laying purposes. Injury is done by both the adult and larva. The former punctures the fruit in feeding and in egg laying, and the grubs live within the fruit and spoil it for market or other purposes. The character and extent of injury vary with different fruits, and while the present paper deals with the insect as an enemy of the peach the statements here made are fairly applicable to other stone fruits, such as plums, cherries, apricots, and nectarines.

Most of the peaches punctured while small soon fall from the effect of the injury or on account of the presence of the developing grubs. After a peach is of some size, about one third grown, most of the larvæ apparently are unable to develop successfully in it, owing to its vigorous growth. There is a considerable period, therefore, when the curculio is able to inflict but little damage to vigorous-growing peaches, though the fruit may be more or less scarred by the feeding and egg punctures, from which gum may exude, especially during moist weather (figs. 4 and 5). As stated elsewhere, these punctures and the exudation of gum greatly favor the brown-rot, forming a nidus for spores of the fungus and furnishing an easy point of infection. After the period of rapid growth of peaches has passed and the ripening process has begun, the curculio larva is able to develop readily in the fruit and, as the beetles are still ovipositing when early and midsummer varieties are ripening, wormy ripe peaches are often to be noted at picking time. The loss caused by worminess of fruit (fig. 6), while often quite important, is perhaps less so than that resulting from the "stings" which deform and scar the fruit. Wormy fruit and that which is scarred to any extent ripen prematurely, as a rule, and in untreated orchards may constitute a considerable proportion of the crop.

LIFE HISTORY AND HABITS.

How the curculio passes the winter.—The curculio passes the winter in the adult or beetle stage under trash in orchards, along fences, terraces, etc., but especially in woods adjacent to orchards. The beetles come out of hibernation in the spring at about the blooming period of the peach, feeding at first upon the buds and foliage and later also upon the fruit.

Occurrence in orchards.—The invasion by the beetles of orchards in spring and the effect on their abundance of neighboring woods have been several times investigated. Much may be done to reduce their number by keeping the orchards and surroundings free from trash. Where practicable, it will be desirable to burn over in early spring woods adjacent to orchards in order to destroy the beetles hibernating there. Jarring records of considerable areas of peach orchards have been made which show the occurrence of the curculio first in large numbers adjacent to woods, terraces, or other favoring places. Table I shows the results of a jarring record made by Messrs. E. W. Scott and E. L. Jenne, at Barnesville, Ga., during 1910. Figure 7 illustrates the arrangement of the trees with respect to their surroundings.

Considering the results of the jarring records for the individual rows, the influence of the woods is very evident. A total of 476 beetles was taken from rows 1 and 2, adjacent to woods, up to March 23, as compared with a total of 61 beetles from the remaining eight rows. Fifteen days after the emergence from hibernation of the beetles began, namely, by March 25, their diffusion had become quite general all over the orchard, though the first one or two rows always showed on a given date a greater number of individuals than any other row. During the season a total of 3,197 beetles was taken from row 1, or 42.64 per cent of all captured. The first three rows adjacent to the woods gave for the season 4,813 beetles, or 64.19 per cent of the total for the entire plat. Between rows 9 and 10, as shown in the diagram, there was a terrace covered with grass and trash, and its influence on the abundance of the insects is also to be noted, more individuals being taken on these respective rows than from any one of the rows 4 to 8, inclusive.

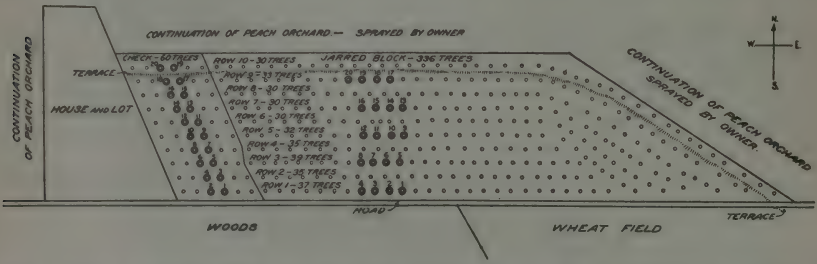

FIG. 7.—Plan of a block of peach trees jarred for the curculio, showing the arrangement of the trees.

The Georgia record also shows that beetles were out in maximum numbers from March 25 to April 3, or about 10 days to 2 weeks after the trees were in bloom. During this period, 4,108 individuals were captured, or 54.79 per cent of the catch for the season. However, during all of May and June the beetles were fairly abundant, but they diminished perceptibly during July and August. The increase in numbers, evident with the third week in August, is perhaps due to the appearance of beetles developing from ripe peaches or those of a second generation, for the development of which some evidence was obtained under laboratory conditions. Apparently all of the beetles had left the trees for hibernation by October 11, as after this date no more individuals were captured.

TABLE I.—*Jarring record for the plum curculio on the peach, Barnesville, Ga., 1910.*

Dates of jarring.	Number of curculio caught, by rows and dates.										Total.
	Row 1.	Row 2	Row 3.	Row 4.	Row 5.	Row 6.	Row 7.	Row 8.	Row 9.	Row 10	
Mar. 10....	16	0	2	0	0	0	0	1	0	0	19
14....	5	1	0	0	1	0	0	0	1	1	9
16....	0	1	0	0	0	0	0	0	0	0	1
18....	3	1	0	0	0	0	0	0	0	1	5
21....	15	1	1	1	0	1	0	0	0	1	20
23....	406	27	10	6	0	6	7	1	5	15	483
25....	460	140	56	45	32	13	14	15	16	49	840
28....	550	125	95	58	38	33	30	33	35	74	1,071
30....	206	77	57	36	21	24	29	21	38	54	563
Apr. 1....	186	74	54	33	18	19	23	18	54	55	534
4....	92	38	45	39	32	29	37	21	45	49	427
6....	93	36	38	17	10	3	2	6	10	28	243
8....	71	23	21	5	3	4	3	6	9	21	166
11....	54	30	16	6	9	10	13	7	7	17	169
13....	34	13	14	4	3	2	5	3	6	11	95
15....	31	8	8	3	0	3	3	1	3	9	69
18....	22	10	8	4	3	3	5	2	5	10	72
20....	5	2	0	1	0	0	0	0	0	4	12
22....	9	11	5	5	2	2	1	3	7	8	53
25....	5	0	1	3	1	0	0	1	2	2	15
27....	3	4	1	1	0	3	2	0	1	1	16
29....	23	8	9	4	2	2	2	4	10	26	90
May 2....	41	21	13	3	7	3	7	6	10	14	125
4....	33	5	5	4	4	2	6	2	6	15	82
6....	12	3	5	1	3	3	0	2	10	13	52
9....	7	5	1	2	0	1	0	0	8	5	29
11....	39	14	3	6	4	2	8	8	9	8	101
13....	13	3	1	0	1	1	1	0	5	6	31
16....	4	1	3	0	1	0	1	0	0	0	10
18....	6	1	0	2	0	0	2	1	2	4	18
20....	37	11	9	5	2	4	6	4	9	11	98
23....	23	6	6	3	3	1	2	1	4	12	61
25....	18	2	3	4	3	0	1	2	4	4	41
27....	15	10	3	3	2	3	1	2	4	6	49
30....	17	10	2	4	3	2	3	2	8	7	58
June 1....	4	1	0	2	2	1	0	0	2	3	15
4....	10	1	1	1	0	2	3	0	6	5	29
7....	81	46	14	7	8	7	8	8	16	36	231
9....	55	14	17	10	6	3	12	11	30	31	189
11....	21	11	6	7	2	4	2	3	3	4	63
14....	44	17	8	2	5	6	5	8	15	17	127
16....	36	25	13	7	4	4	3	4	16	19	131
18....	35	21	9	8	4	7	6	5	21	6	122
20....	15	6	7	2	2	1	4	1	8	8	54
22....	8	2	3	1	2	2	0	0	8	8	34
24....	16	7	2	4	2	3	2	2	8	3	49
27....	16	5	5	4	2	3	3	3	2	8	51
29....	6	7	3	1	3	0	0	1	0	8	29
July 2....	4	3	2	1	1	0	2	1	2	1	17
5....	13	3	2	2	0	1	0	1	0	2	24
8....	6	4	0	0	0	1	0	1	0	4	16
11....	4	3	1	4	2	0	3	1	0	5	23
25....	13	5	3	3	2	0	0	1	3	4	34
29....	12	6	5	3	0	0	0	0	2	1	29
Aug. 2...	10	2	1	1	1	0	0	1	5	3	24
5....	1	3	2	0	0	0	0	0	0	2	8
8....	5	2	2	0	0	0	0	0	0	1	10
Sept. 2....	65	10	4	8	1	1	3	0	2	25	119
5....	36	13	8	3	1	2	2	0	5	8	78
10....	7	1	3	0	1	0	2	0	0	4	18
12....	32	3	4	0	4	1	1	1	2	9	57
16....	14	4	2	0	1	0	0	1	0	2	24
23....	16	5	4	1	2	0	0	0	1	3	32
27....	3	3	1	0	0	0	0	0	0	2	9
30....	8	0	1	1	0	0	0	0	0	1	11
Oct. 4....	1	2	0	0	0	0	0	0	1	0	4
7....	3	1	0	0	0	0	0	0	0	1	5
11....	13	2	1	0	2	0	0	0	1	2	21
15....	0	0	0	0	0	0	0	0	0	0	0
18....	0	0	0	0	0	0	0	0	0	0	0
22...	0	0	0	0	0	0	0	0	0	0	0
Total.	3,197	975	641	393	269	229	275	227	503	788	7,497

Egg-laying habits.—Peaches are less suitable for the egg-laying purposes of the curculio than smooth-skinned fruits, such as plums, apples, etc. Observations by Mr. Jenne indicate that the fuzz may be so copious on young peaches as to prevent the puncturing of the skin by the beetle. He observed that eggs were frequently deposited at the bottom of a tubular boring excavated down in the fuzz as far as the skin of the peach, which was usually scraped somewhat, later resulting in a russet spot on the fruit. In older fruit, however, the female is able to place her eggs under the skin in about the usual manner. In ovipositing, a hole is first excavated through the skin and into the flesh, about as deep as her snout will reach. Turning around, an egg is inserted by means of the ovipositor. Once more turning around, the snout is used to push the egg into the egg cavity and to fill it with bits of surrounding tissue. The next step is to cut the characteristic crescent slit at one side of the egg cavity, the excavation extending back under the egg to prevent its being crushed by the rapid growth of the fruit. Egg and feeding punctures on a newly set plum are shown in figure 8, much enlarged.

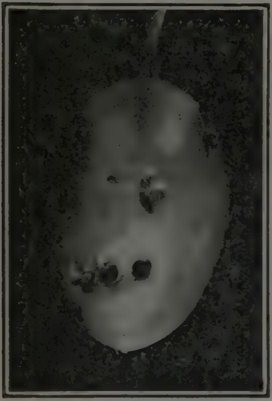

FIG. 8.—Egg and feeding punctures of the curculio on a young plum.

Period of oviposition and number of eggs laid.—Egg laying begins as soon as the young fruit is of sufficient size and may continue for several months, depending upon the vitality of the individual beetles. Most of the eggs, however, are laid during the first six or eight weeks after egg laying begins. Many records of the number of eggs deposited by the curculio in plums, peaches, apples, etc., have been made in different localities. Some of these data are shown in Table II. A total of 12,602 eggs is shown from the seven localities.

TABLE II.—*Combined weekly egg-laying records of the plum curculio for various localities and the percentage of eggs deposited within two, four, six, and eight weeks from confinement.*

Locality.	Number of beetles ovipositing.	Total number of eggs laid each week by all beetles of the respective localities.								
		First week.	Second week.	Third week.	Fourth week.	Fifth week.	Sixth week.	Seventh week.	Eighth week.	For remainder of period.
College Park, Md.	9	496	760	414	289	192	98	46	23	153
Youngstown, N. Y.	8	192	186	201	234	204	140	68	37	32
North East, Pa.	10	81	183	197	94	54	48	18	66	46
Washington, D. C.	4	232	213	242	153	128	108	81	21	46
Myrtle, Ga.	9	58	62	41	176	50	83	48	40	130
Siloam Springs, Ark.	29	254	300	343	673	619	545	536	350	1,104
Douglas, Mich.	18	72	259	329	423	229	89	13	.....	.....
Total	87	1,385	1,963	1,767	2,042	1,476	1,111	810	537	1,511

Table II.—*Combined weekly egg-laying records of the plum curculio for various localities and the percentage of eggs deposited within two, four, six, and eight weeks from confinement*—Continued.

Locality.	Total number of eggs.	Number of eggs per individual.			Percentage of total eggs deposited by end of—			
		Maximum.	Minimum.	Average.	Second week.	Fourth week.	Sixth week.	Eighth week.
College Park, Md.	2,471	436	62	274.56	50.83	79.28	91.02	93.81
Youngstown, N. Y.	1,294	257	72	161.75	29.21	62.83	89.40	97.53
North East, Pa.	787	122	48	78.70	33.55	70.65	83.48	94.17
Washington, D. C.	1,224	557	126	306.00	36.36	68.63	87.91	96.24
Myrtle, Ga.	688	154	1	76.44	17.44	48.98	68.31	81.10
Siloam Springs, Ark.	4,724	388	4	162.97	11.73	33.23	57.88	76.63
Douglas, Mich.	1,414	201	25	78.56	23.41	76.59	99.08	100.00
Total	12,602							
Average for all localities				144.85	26.57	56.79	77.32	88.01

At College Park, Md., the greatest number deposited by any one female was 426 and the minimum 62, with an average of 274.56 eggs for the individuals under observation. At Youngstown, N. Y., the maximum is 257 and the minimum 72, with an average of 161.75 eggs. At Washington, D. C., under laboratory conditions, a single individual deposited 557 eggs, which is the highest of all records thus far obtained for this insect; the lowest number deposited was 126 and the average for the 4 beetles under observation was 306. At Myrtle, Ga., this range was from 154 as a maximum to a minimum of 1, with an average of 76.44 per individual. At Siloam Springs, Ark., the records include an unusually large number of eggs, namely, 4,724, from 29 beetles. These records show a maximum of 388 and a minimum of 4 eggs, with an average for all pairs of 162.97 eggs. At Douglas, Mich., the records show a range from 201 to 25, with an average for the 18 individuals of 78.56 eggs. The final average number of eggs per female for all localities above mentioned is 144.85, with a range of from 1 to 557.

As shown under the heading "Percentage of total eggs deposited by end of second, fourth, sixth, and eighth week," the proportion deposited by a given time varies for the different localities. There is, however, a general agreement in that the great majority of the eggs have been placed by the end of eight weeks. Approximately, one-fourth of the total eggs are deposited during the first two weeks; one-half have been deposited by the close of the first month; three-fourths within six weeks; and about 88 per cent of the total within eight weeks after the oviposition begins.

Time spent in the fruit.—Records of the time spent in the fruit as the egg and larva have been determined for many individuals and in various localities, including Illinois, District of Columbia, western New York, Georgia, Arkansas, and Michigan.

In all localities the majority of the larvæ emerged within three weeks after the eggs were laid, and, with one exception, emergence had practically ceased by the close of the fourth week.

Time spent in the soil.—When full grown the larva deserts the fruit and burrows below the surface of the soil. Practically none of the larvæ go deeper than 3 inches and the great majority penetrate not more than 2 inches. A small cell is made where the pupal stage is passed and where transformation to the adult or beetle occurs. Some days are spent in the soil by the larva before changing to the pupa, and the newly formed adult may not emerge for several days or even weeks, especially if the ground be dry. The effect of a shower, however, is to bring the new-generation beetles out in numbers.

A large number of observations have also been made on the length of time spent in the soil by different individuals, including a total of several thousand and from about the same localities as already mentioned. All of these observations go to show that comparatively few insects complete their underground transformations in less than three weeks from the time of entering the soil as larvæ. In from four to five weeks, however, the great majority of the beetles are out and by the close of the sixth week emergence has practically ceased.

Time required for transformation from egg to adult.—The average time spent in the fruit for the numerous localities investigated proved to be 19.48 days, and the average time spent in the ground was found to be 30.89 days, giving an average life-cycle period for the insect of 50.27 days.

Complete life-cycle observations were also made on a total of 597 individuals from many parts of the country, which gave a final average for the period per individual of 50.71 days, differing only a fraction of a day from the time determined in an essentially different manner. Approximately 50 days would therefore appear to be the average life-cycle period for the plum curculio for the country as a whole. The range though, will vary considerably and as actually determined in the case of the individual records was from 37 to 58.45 days.

Habits of beetles from emergence until hibernation.—After emergence, beetles of the new generation feed upon various fruits and plants until fall, when they enter hibernation quarters, appearing the following spring, as already stated. While there is some evidence to indicate that there may be a small second generation in the South, this will be comparatively insignificant and for practical purposes the insect produces but one generation annually. The beetles which develop one summer live over the following winter, ovipositing during the spring and summer, and gradually die off, until by early fall practically all of them have disappeared. The life of the more hardy beetles is thus seen to be some 12 or 14 months

RESULTS OF SPRAYING EXPERIMENTS AND DEMONSTRATIONS DURING 1910.

During the season of 1910 the same experiments were carried out as during 1909, which were reported in Circular 120 of the Bureau of Entomology and in Bulletin 174 of the Bureau of Plant Industry, and in addition the recommendations given in these publications were put in effect on a commercial scale to serve as an object lesson for growers. During 1909 the experiments made in the Hale orchard at Fort Valley, Ga., included the treatment of 1,100 Elberta trees for the control of peach scab, brown-rot, and curculio. The self-boiled lime-sulphur mixture (8–8–50) plus 2 pounds of arsenate of lead was used.

This combined treatment gave the following results: At picking time 95.5 per cent of the fruit on the sprayed block was free from brown-rot, 93.5 per cent free from scab, and 72.5 per cent free from curculio. On the unsprayed block only 37 per cent of the fruit was free from brown-rot, 1 per cent free from scab, and 2.5 per cent free from curculio injury. In packing the fruit for market it was found that the yield of merchantable fruit on the sprayed block was ten times as great as from the unsprayed block containing the same number of trees.

During the season of 1910 neither the brown-rot nor the plum curculio was so abundant in Georgia as the year previous, and the contrast between the sprayed and unsprayed blocks was, therefore, not so striking. Nevertheless, the very satisfactory results obtained fully substantiated the conclusions previously reached as to the value of spraying.

The work in Georgia was carried out at Fort Valley, Barnesville, and at Baldwin. At Fort Valley a block of 1,064 nine-year-old Elberta trees was treated in the orchard of the United Orchard Company. In addition to numerous experiments planned to show the effect of treatments at different times and with different mixtures, the demonstration treatment was put in effect on a block of 848 Elberta trees, a similar number being left unsprayed for purposes of comparison. The trees were sprayed (1) as the calyxes were shedding, April 1, with 2 pounds of arsenate of lead and 3 pounds of lime in each 50 gallons of water; (2) two to three weeks later, April 19 and 20, with 8–8–50 self-boiled lime-sulphur and 2 pounds of arsenate of lead; (3) on June 17, about a month before the fruit ripened, with self-boiled lime-sulphur alone.

In order to determine the effect of the treatments, the fruit at picking time (July 12 to 15) was gathered from 68 trees in the sprayed block and from 63 trees in the unsprayed block. This fruit was carefully graded into "merchantable" and "culls," with the results shown in Table III.

Table III.—*Results of demonstration spraying in the peach orchard of the United Orchard Company, Fort Valley, Ga., 1910.*

Plat.	Yield.	Merchantable fruit.	Culls.	Fruit affected with brown-rot.
	Bushels.	*Per cent.*	*Per cent.*	*Per cent.*
68 trees (sprayed)	101	86.2	13.7	5.3
63 trees (not sprayed)	92	54.6	46.4	20.0

It will be noted that from the 68 sprayed trees there was a total yield of 101 bushels, of which 86.2 per cent was merchantable and 13.7 per cent was culls. On the unsprayed block of 63 trees there was a total yield of 92 bushels of fruit, of which 54.6 per cent was merchantable and 46.4 per cent was culls, a gain in merchantable fruit due to the treatments of 31.6 per cent.

In the orchard of Mr. S. H. Bassett, also at Fort Valley, Ga., a block of 700 seven-year-old Elberta trees was sprayed as a demonstration and a like number of trees left unsprayed for comparison. The trees were sprayed as the calyxes were shedding, April 5, with 2 pounds of arsenate of lead to each 50 gallons of water and again on April 22 with self-boiled lime-sulphur (8–8–50) and 2 pounds of arsenate of lead. Owing to the difficulty of getting water, this block received no further treatment. On July 7, when the first picking of the crop was being made, the sprayed and unsprayed blocks were carefully examined for the purpose of making an estimate of the results of the treatment. The fruit on the sprayed block was highly colored and practically free from scab, brown-rot, and curculio. No specimens of fruit affected with these troubles could be found in a search of two hours throughout the block. The crop was decidedly heavier on the sprayed trees than on the unsprayed, the fruit from the latter having dropped from the effect of these combined troubles. In looking over the unsprayed block, it was estimated that 50 to 60 per cent of the crop had been destroyed or rendered unmerchantable by curculio, brown-rot, and scab.

In the operations at Barnesville, Ga., the same plan of spraying was carried out on a commercial scale in two different orchards. The improved condition of the fruit on the sprayed blocks in both of these orchards was a matter of much comment by the fruit growers in that section.

Owing to the almost complete absence of the curculio and the small amount of brown-rot in these orchards, the results were not as well marked as those obtained elsewhere. The peach scab, however, was quite abundant on the unsprayed fruit and practically absent on the sprayed blocks.

In the orchard of Mr. S. M. Marshburn, the demonstration treatment was given to 926 Elberta trees, 212 trees being left untreated for comparison.

From the sprayed trees the yield was 209 crates of extra fancy fruit, 587 crates of fancy fruit, with 51¾ bushels, or 96 crates, of culls, the total merchantable fruit being 92.02 per cent.

On the unsprayed trees the yield was 15¾ crates of extra fancy fruit, 135¼ crates of fancy fruit, with 21½ bushels, or 28⅔ crates, of culls, the percentage merchantable being 84.02.

In the A. O. Murphy orchard, the yield from 485 sprayed Elberta trees was 211 crates of extra fancy fruit, 272 crates of fancy fruit, with 68½ bushels, or 91⅓ crates, of culls, the total percentage merchantable being 84.09.

On the 110 unsprayed Elbertas in this orchard the yield was 8½ crates of extra fancy fruit, 109 crates of fancy fruit, and 45¼ bushels, or 60⅓ crates, of culls, the percentage merchantable being 66.07.

In the orchard of Mr. A. M. Kitchen, at Baldwin, Ga., experiments and demonstrations were conducted on the Carman, Hiley, Elberta, and Summerour, or Atlanta, varieties, 2,000 trees in all being treated and a similar block left untreated. The trees were 7 years old and bore a fair crop of fruit, although the crop was rather light in portions of the orchard. The Elberta and Summerour varieties were sprayed (1) as the calyxes were shedding, April 7 and 8, with arsenate of lead, 2 pounds to 50 gallons of water; (2) on April 27 and 28, with 8–8–50 self-boiled lime-sulphur and 2 pounds of arsenate of lead; and (3) on June 17 and 18, about a month before the fruit ripened, with 8–8–50 self-boiled lime-sulphur. The Carman and Hiley varieties received the same treatment, with the omission of the third application. At picking time the fruit from 5 to 11 sprayed trees and a like number of unsprayed trees in each variety was sorted and the results are shown in Table IV.

TABLE IV.—*Results from spraying the Carman, Hiley, Elberta, and Summerour varieties of peaches at Baldwin, Ga., 1910.*

Varieties and dates of spraying.	Total fruits.	Fruit affected with brown-rot.	Fruit affected with scab.	Fruit badly affected with scab.	Merchantable fruit.	Culls.
	Number.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Sprayed:						
Carman, Apr. 7 and 27	1,884	0.1	15.9	0.00	97.6	2.4
Hiley, Apr. 7 and 27	1,446	.2	28.0	.00	96.3	3.7
Elberta, Apr. 7, 27, and June 17	3,443	.7	41.4	.03	97.7	2.3
Summerour, Apr. 7, 27, and June 17.	4,360	9.3	[1] 7.7	.80	82.6	17.4
Unsprayed:						
Carman	1,417	31.8	92.9	16.40	40.2	59.8
Hiley	739	28.1	92.4	19.00	51.5	48.5
Elberta	1,291	70.0	100.0	16.00	16.9	83.1
Summerour	5,308	54.8	[1] 91.7	72.60	7.5	92.5

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[1] In sorting this variety, fruits that showed only a few inconspicuous spots were not counted as scabby, while all the affected fruit of the other varieties was counted.

It will be seen from Table IV that the brown-rot was thoroughly controlled, even where 70 per cent of the unsprayed fruit rotted, as was the case with the Elberta. The scab was also held down so that it was commercially negligible. The Summerour is particularly susceptible to scab, and has been unprofitable in Mr. Kitchen's orchard on account of this disease. On the unsprayed trees 72.5 per cent of the fruit was badly affected with scab, while less than 1 per cent of the sprayed fruit was badly affected. By referring to the column showing the percentage of merchantable fruit in Table IV it will be seen that from 82.6 to 97.7 per cent of the sprayed fruit was merchantable and from 7.5 to 51.5 per cent of the unsprayed fruit was merchantable. The difference between these two sets of figures represents the difference between success and failure.

In Table V are shown the results from 12 sprayed and 12 unsprayed Elberta trees in the same orchard and given the same treatment as those considered in Table IV, but located in a different section of the orchard. The fruit was picked from July 26 to August 1 and sorted with reference to brown-rot, scab, and curculio. To determine the presence or absence of the curculio all the fruit was sliced into several pieces.

TABLE V.—*Results from 12 sprayed and 12 unsprayed Elberta peach trees at Baldwin, Ga., 1910.*

Plats.	Total fruits.	Fruit affected with scab.	Fruit badly affected with scab.	Fruit affected with brown-rot.	Fruit affected with curculio.	Merchantable fruit.	Culls.
	No.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Sprayed	5,197	39.26	0.03	0.90	13.15	97.61	2.39
Unsprayed	3,907	100.00	9.29	18.04	51.19	46.49	53.51

It will be seen from Table V that 0.9 per cent of the sprayed fruit was affected with brown-rot, 39.26 per cent with scab (practically none of which was bad), and 13.15 per cent with curculio, while 18.04 per cent of the unsprayed fruit was affected with brown-rot, 100 per cent with scab, and 51.19 per cent with curculio. It is also shown that 97.61 per cent of the sprayed fruit was merchantable, as against 46.49 per cent of the unsprayed fruit. Had all the fruit infested with curculio been thrown out the percentage of merchantable fruit from both the sprayed and the unsprayed trees would not have been quite so high. Much of the infestation consisted of young worms just hatched, and in such cases the market value of the fruit had not been materially affected. In addition to these 12 trees the crop from a block of 70 sprayed and 70 unsprayed Elberta trees was sorted and packed for the market. It was found that 97.04 per cent of the fruit of the sprayed block was merchantable, leaving 2.96 per cent as culls. From the unsprayed block only 54.11 per cent of the crop was merchantable and 45.89 per cent unmerchantable, a gain of 42.93 per cent.

A block of 1,000 Summerour trees, which is a late-maturing variety, ripening at Baldwin last season, August 27 to 31, was given the same treatment received by the Elbertas. In order to determine the commercial results the crop from 70 sprayed trees and the same number of unsprayed trees was graded at the packing house. It was found that 85 per cent of the sprayed fruit was merchantable, leaving 14.98 per cent unmerchantable. Only 6.49 per cent of the unsprayed fruit from 70 trees was merchantable, 93.51 per cent being totally unfit for market. This shows a gain from spraying of 78.53 per cent. This great loss was due to the combined effect of the curculio, brown-rot, and scab, although the latter was the most prominent trouble. These commercial results show conclusively that even under severe conditions the combination treatment will effectually control these troubles.

It will be understood that the combination treatment for these diseases and curculio is in effect a compromise. Considered only from the insect standpoint, an additional application of arsenate of lead would be desirable, but a third application of the poison is as a rule unsafe. Nevertheless, the benefits from two applications of arsenate of lead has been very marked. In order to show more in detail the effect of two such treatments on the curculio, Table VI is presented, showing the results of an examination for curculio infestation of the dropped fruits during the season, as well as those on the trees at picking time, 12 trees in the sprayed block and 12 trees in the unsprayed block being examined.

TABLE VI.—*Results of spraying Elberta peaches for plum curculio, Baldwin, Ga., 1910.*

Plat No.	Treatment.	Tree No.	Fruit from ground.		Fruit from tree.		Total number of fruits.	Total number of fruit infested.	Sound fruit.[1]
			Total number.	Number infested.	Total number.	Number infested.			
									Per cent.
1	First application, Apr. 7–8, arsenate of lead, 2 pounds to 50 gallons of water; second application, 2 pounds of arsenate of lead in self-boiled lime-sulphur wash (8-8-50), Apr. 27–28; third application, lime-sulphur wash only (8-8-50), June 17–18.	1	447	7	589	26	1,036	33	96.81
		2	119	8	465	45	584	53	90.92
		3	177	10	388	65	565	75	86.72
		4	363	24	606	76	969	100	88.63
		5	161	10	335	61	496	71	85.68
		6	96	12	409	26	505	38	92.47
		7	99	2	358	38	457	40	91.23
		8	222	22	293	33	515	55	89.32
		9	702	25	412	123	1,114	148	86.71
		10	224	6	476	83	700	89	87.28
		11	68	7	410	50	478	57	88.07
		12	348	17	456	58	804	75	90.67
		Total.	3,026	150	5,197	684	8,223	834	....
2	Untreated..................	1	188	115	324	178	512	293	42.77
		2	187	83	385	132	572	215	62.41
		3	147	85	280	155	427	240	43.79
		4	839	114	648	239	1,487	353	76.26
		5	76	56	129	79	205	135	34.14
		6	605	165	471	189	1,076	354	67.10
		7	192	71	177	94	369	165	55.28
		8	318	55	299	147	617	202	67.26
		9	68	67	388	251	456	318	30.26
		10	143	67	176	137	319	204	36.05
		11	214	110	347	231	561	341	39.21
		12	274	100	283	168	557	268	51.88
		Total.	3,251	1,088	3,907	2,000	7,158	3,088	....

[1] The average of sound fruit on treated trees was 89.85 per cent; on untreated trees, 56.85 per cent.

In the sprayed block 8,223 fruits were obtained, of which 834, or 10.15 per cent, were infested. From the unsprayed block there was a total of 7,158 fruits, of which 3,088 were infested, the percentage of sound fruit being 56.85, a gain in yield of 33 per cent of fruit free from curculio infestation.

EXPERIMENTS IN WEST VIRGINIA, 1910.

In order to demonstrate the control of peach scab and to determine how much spraying is required on late varieties, an experiment was conducted in the orchard of L. P. Miller & Bros., at Okonoko, W. Va., during 1910. There are about 600 acres of 12-year-old trees in this orchard, and it is composed of a large number of varieties, beginning with Southern Early and ending with Bilyeu. Until summer spraying was undertaken in 1908 the peach scab had been most disastrous to the crops in this orchard, about one-half of the fruit being lost every year. Spraying, however, largely overcame the trouble, and in 1910 the loss was comparatively small, notwithstanding the difficulty of thoroughly spraying such a large orchard at the proper time.

The spraying experiments were confined to the Elberta, Salway, and Bilyeu, and about 500 trees each of these varieties were used. The Bilyeu set a good crop, while the crop of Elberta and Salway was only medium to light, but ample for an experiment. For the most part the weather was unfavorable for good work. During the time the first and second applications were being made it was cloudy and showery and the day following the second application it rained rather hard all day. The Elberta trees were sprayed according to the following plan:

Plat 1.—Self-boiled lime-sulphur and arsenate of lead, one month after petals fell, May 11.

Plat 2.—Self-boiled lime-sulphur with arsenate of lead, one month after petals fell, and self-boiled lime-sulphur alone, one month later, May 11 and June 15.

Plat 3.—Self-boiled lime-sulphur, one month after petals fell and one month later, May 11 and June 15.

Plat 5.—Self-boiled lime-sulphur six weeks after petals fell and one month later, May 26 and June 28.

Plat 6.—Commercial lime-sulphur, 1 to 100 with arsenate of lead and lime, one month after petals fell, and with lime only one month later.

Plat 0.—Check; untreated.

At picking time, August 22 to 26, the crop, including windfalls, from four trees in each sprayed plat and six unsprayed trees was sorted to determine the percentage of fruit affected with scab and the percentage of merchantable fruit. The results are shown in Table VII.

TABLE VII.—*Results of treatment for peach scab on the Elberta variety, Okonoko, W. Va., 1910.*

Plats.	Total fruits.	Fruit affected with scab.	Fruit badly affected with scab.	Merchantable fruit.	Culls.
	Number.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1	1,322	65.2	3.0	85.1	14.9
2	1,566	20.9	0.1	95.5	4.5
3	2,277	20.2	1.4	93.1	6.9
5	1,819	55.8	0.9	93.6	6.4
6	1,924	49.3	1.5	93.9	6.1
Check	2,918	99.6	41.1	53.7	46.3

The third column of the above table shows the percentage of fruit affected with scab, including fruit so slightly affected that its market value was not materially reduced, while the fourth column shows the percentage of badly affected, unmerchantable fruit. The fifth column shows the percentage of good, merchantable fruit obtained from each plat, while the sixth column shows the percentage of culls due to scab, brown-rot, curculio, and other causes.

Plat 1 received only one application, and the results were all that could be expected in a wet season, such as last spring. Although 65.2 per cent of the fruit was affected with scab, only 3 per cent of it was badly affected.

Plats 2 and 3, which were sprayed twice, gave the best results, only a little more than 20 per cent of the fruit in each being affected with scab. Most of this scab infection was commercially negligible, the spots being small and rather inconspicuous. In plat 2 less than 1 per cent of the fruit was badly affected, and in plat 3 only 1.4 per cent was so affected. The only difference in the treatment received by these two plats was the use of arsenate of lead with the self-boiled lime-sulphur in the first application on plat 2. This made no difference in the control of scab. It apparently raised the percentage of merchantable fruit, plat 2 having 95.5 per cent and plat 3 having 93.1 per cent. This difference would certainly have been greater had there been more curculio in the orchard.

The good results obtained from the treatment of these two plats may be better appreciated by comparing them with the results from the unsprayed trees. Practically all (99.6 per cent) of the unsprayed fruit was affected with scab and 41.1 per cent of it was badly affected. Only 53.7 per cent of the fruit was suitable for market, leaving 46.3 per cent of culls.

Plat 5 received the same treatment as plat 3, except that both applications were delayed two weeks. The results indicate that one month after the petals fall is a better time to begin spraying for scab than two weeks later.

Plat 6, which was sprayed with commercial lime-sulphur solution, 1 gallon to 100 gallons of water, had only 1.5 per cent of fruit badly affected with scab, although 49.3 per cent of it was affected more or less. These results indicate that the scab can be held in check by a very dilute solution of the lime-sulphur solution. It burned the foliage considerably and caused some of the leaves to drop, but the injury almost disappeared as the season advanced and the fruit matured in good condition.

A similar test was made on the Salway variety, which ripens some four weeks later than the Elberta. There were four sprayed plats, consisting of about 80 trees each, and 17 trees were left untreated for the purpose of comparison. The self-boiled lime-sulphur (8–8–50) was used in each application, and arsenate of lead at the rate of 2 pounds to each 50 gallons was added in the first application only.

On September 22 and 23 the crop from four trees in each plat was sorted for scab and brown-rot, and the results are shown in Table VIII. In this case the classification of scabby fruit was made on a commercial basis; that is, the fruit having only a few small specks of scab, which did not materially detract from its market value, was not classed as scabby. The figures given in the table therefore represent the percentage of fruit so badly affected as to have but little value on the market.

TABLE VIII.—*Results of spraying on the Salway variety in the Miller orchard, Okonoko, W. Va., 1910.*

Plat No.	Dates of spraying.	Total fruits.	Scabby fruit.	Rotted fruit.
		Number.	*Per cent.*	*Per cent.*
8	(1) One month after petals fell, May 12; (2) June 17; (3) July 15	1,557	5.5	2.5
9	(1) One month after petals fell, May 12; (2) June 17	1,599	5.3	1.9
10	(1) One month after petals fell, May 12	1,132	27.2	6.8
11	(1) Six weeks after petals fell, May 26; (2) June 28	1,065	5.8	1.3
12	Check; not sprayed	2,349	87.5	37.6

It will be observed that the results from plat 8, which had three applications, are about the same as those from plat 9, which had two applications, the scab and brown-rot having been almost completely controlled in both cases. The results of the treatment of plat 9 are shown in figures 9 and 11. The superiority of two treatments over one may be seen by comparing plats 9 and 10. The latter received only one application and 27.2 per cent of the fruit became affected with scab, while only 5.3 per cent of the crop on plat 9 was affected. Plat 11 received the same treatment as plat 9, except that the applications on plat 11 were delayed two weeks, the object being to determine the best time to begin the spraying. In this case there was very little difference in the results from the two plats.

Of the fruit from the unsprayed trees, 87.5 per cent was rather badly affected with scab and 37.6 per cent was affected with brown-rot, as shown in figures 10 and 12. In other words, the unsprayed crop was almost a total loss.

The Bilyeu variety was given the same treatment as that applied to Salway and the results were about the same. In this case the fruit was not sorted and counted, but at picking time comparative notes were made, attempting to show the estimated percentages of brown-rot and scab. Fully 50 per cent of the unsprayed fruit was lost on account of these diseases, while there was a loss of only about 5 per cent of the fruit sprayed twice, although much of it showed some slight spotting with scab. On the plat sprayed three times the scab was almost entirely prevented. In most cases three treatments will be necessary for the best results against scab on late-maturing varieties like the Bilyeu.

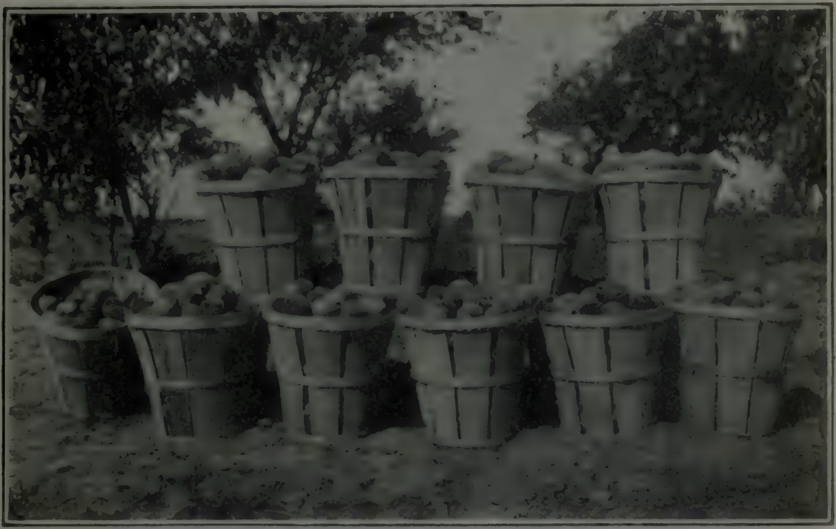

FIG. 9.—Crop from four Salway trees sprayed twice, Okonoko, W. Va. Scabby fruit in single basket on the left; remainder of the crop sound.

EXPERIENCE OF FRUIT GROWERS.

Following the recommendations of the United States Department of Agriculture, a considerable number of fruit growers have adopted the combination treatment, and in Georgia during 1910 perhaps not less than one-fourth of the peach orchards were sprayed for the curculio, brown rot, and scab. In connection with the department's experiments at Fort Valley, Barnesville, and Baldwin, Ga., an effort was made to give personal instruction to as many orchardists as possible in order to start them in the work, and by visits and by correspondence assistance was rendered to growers in other parts of the State. Thus at Fort Valley the Hale Georgia Orchard Co. sprayed three times its entire bearing orchard of about 100,000 trees. The same schedule of treatments was also adopted by Mr. W. C. Wright in his orchard of 60,000 trees and by others in the immediate neighborhood. Also at Marshallville, Ga., the treatment was adopted by Mr. S. H. Rumph and other leading growers, the total number of trees sprayed in this general section aggregating about a million.

At Barnesville, Ga., practically all of the large orchardists used the combined spray, aggregating not less than 500,000 trees. At Baldwin, Ga., some of the leading growers sprayed not less than 100,000 trees. Messrs. Stranahan Bros., of Warm Springs, Ga., have been spraying for the past three years and were among the first large peach orchardists to adopt the lime-sulphur treatment even before it was out of its experimental stage. Also around Adairsville and at numerous other points in Georgia spraying was adopted by the leading growers, at least 2,000,000 trees for the State as a whole being sprayed. Considering all of the Southeastern States it is probable that in this territory 3,000,000 trees were sprayed during 1910.

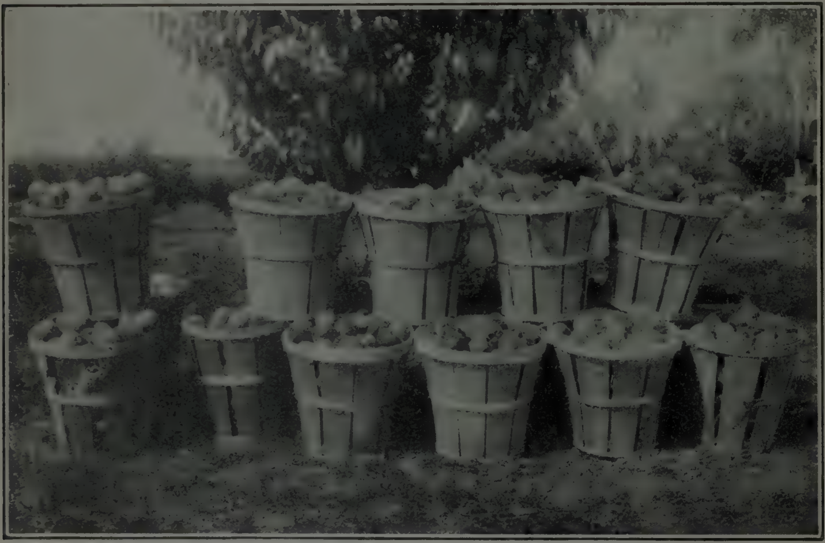

FIG. 10.—Crop from four unsprayed Salway trees, Okonoko, W. Va. Sound fruit in three baskets on the left; remainder of the crop scabby.

Considerable spraying has also been done by peach orchardists in West Virginia, western Maryland, and Pennsylvania, including a total of perhaps 1,000,000 trees. The treatment has also been adopted by some growers in Illinois, Missouri, and Arkansas, aggregating about

500,000 trees, making on a conservative estimate a grand total of 4,500,000 to 5,000,000 trees sprayed during 1910 with the self-boiled lime-sulphur wash and arsenate of lead.

We have been able to personally examine some of these orchards, and have had reports from many of the orchardists regarding the results of the treatment. So far as it has been possible to determine, the results have been uniformly satisfactory and the slight injury from the spray comparatively unimportant. It seems rather remarkable that so many growers in different parts of the country should be so successful in using a new treatment for the first time. This may be taken to indicate the entire practicability of the recommendations.

EFFECT OF SPRAYING ON THE QUALITY OF THE FRUIT.

The good results from the treatment do not end with the control of the curculio, scab, and brown-rot. The sprayed fruit is as a rule somewhat larger, much more highly colored, and firmer than unsprayed fruit. It keeps longer, carries to the market in better condition, and brings better prices. A carload of Elberta peaches shipped from Baldwin, Ga., on July 29 contained 166 crates of sprayed fruit and 324 crates of unsprayed fruit. This fruit was sold on the New York market on August 2, the 166 crates of sprayed fruit bringing $2.50 per crate, while the 324 crates of unsprayed fruit brought an average of $1.75 per crate, a difference of 75 cents per crate in favor of the sprayed fruit.

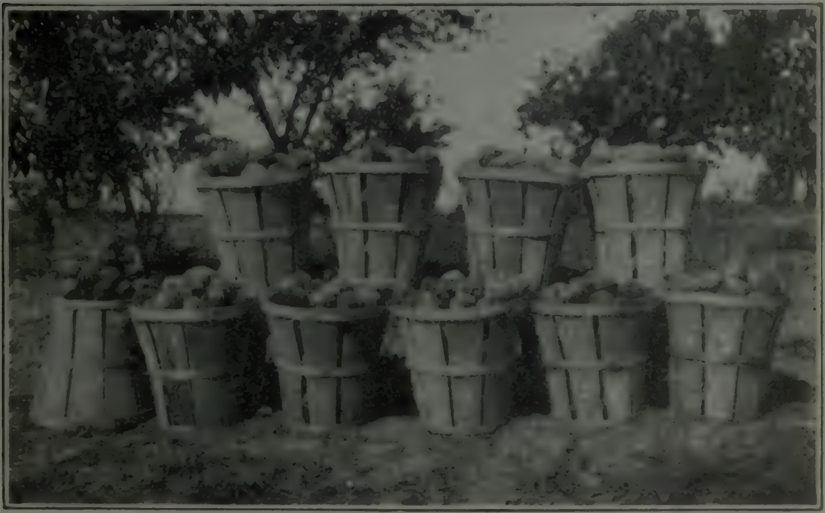

FIG. 11.—Crop from four Salway trees sprayed twice, Okonoko, W. Va. Rotten fruit in upturned basket on the left; remainder free from rot.

The effect of the treatments is to fairly clean the fruit from disease and to put it in a more or less sterilized condition, adding greatly to its keeping quality. This superiority of sprayed as against unsprayed fruit is one of the marked benefits and has been noted by all growers who have adopted the treatment.

On July 14 sprayed and unsprayed Elberta fruit in the Hale orchard at Fort Valley, Ga., was picked and packed for a shipping test, but owing to a car shortage was not shipped. There were 64 crates of unsprayed fruit and 400 crates of sprayed fruit. This fruit was stacked out on the ground where it remained in the sun and during occasional showers of rain until July 18 (4 days) and then 6 crates of each lot were examined for brown-rot. It was found that 62.7 per cent of the unsprayed fruit had rotted, while only 8 per cent of the sprayed fruit was so affected, showing conclusively the better keeping quality of the latter.

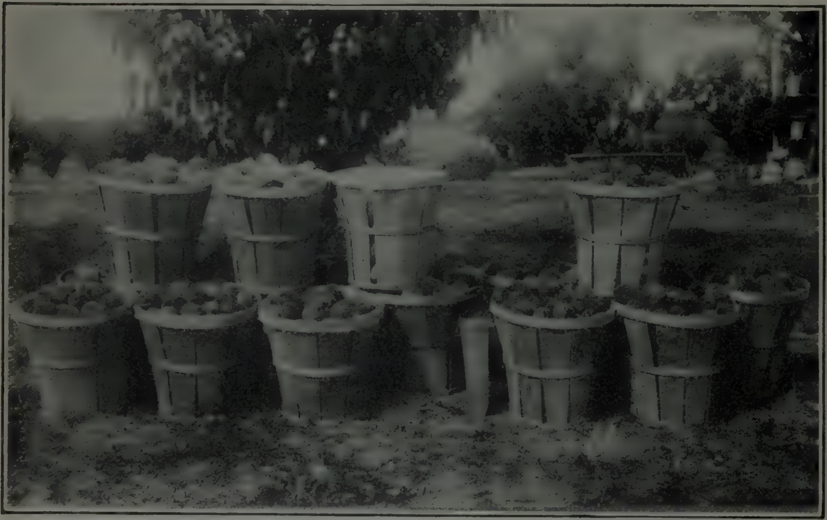

FIG. 12.—Crop from four unsprayed Salway trees, Okonoko, W. Va. Fruit in six baskets on the right affected with brown-rot; the remainder free from rot, but scabby.

EFFECT OF THE SELF-BOILED LIME-SULPHUR WASH ON SCALE INSECTS.

Observations and experiments go to show that, when used as a summer spray, the effect of the self-boiled lime-sulphur wash on the control of scale insects which may be present on the trees, especially the San Jose scale, is important. While to secure the best results in the control of scale insects it would be desirable to coat the limbs and twigs more thoroughly than is accomplished in ordinary summer spraying, nevertheless in the course of the work as practiced against the curculio, brown-rot, and scab noticeable good is accomplished. Although the spray is not strong enough to kill many of the adult scale insects, it is effective to an important extent in bringing about the death of the young scales. Experiments made by the Bureau of Entomology in the use of the self-boiled lime-sulphur wash as a summer spray for the San Jose scale[1] have shown that two or three applications will result in a marked improvement in the condition of the trees by fall. The effect of the wash is to prevent the settling of the young scales upon the twigs and branches, so that by the close of the season the trees are largely free from the insects.

Further observations are necessary to determine just how much benefit will result from these applications in the control of scale insects, but it seems probable in peach orchards regularly sprayed for the curculio and for scab and brown-rot that the usual winter treatments for the San Jose scale may be reduced to perhaps one application every two or three years. Any observant orchardist should be able to determine for himself the necessity for winter treatments, depending upon the abundance of the scale insects. The lime-sulphur wash is furthermore effective against numerous other sucking insects, especially plant lice, which may be present on the trees.

PREPARATION AND USE OF THE SPRAY.

Spraying for the brown-rot, scab, and curculio does not differ in principle from the usual spraying practices. It is essential that an efficient spraying outfit be employed, so that the work may be done expeditiously and with thoroughness. Where the orchard interest is at all important it will be desirable to employ a power sprayer, such as a gasoline or compressed-air outfit. Excellent work, however, may be done with the ordinary barrel sprayer, which is suitable for orchards of a few hundred trees. In applying the spray, all parts of the tree should be reached. This is especially important in the first application, which is directed principally against the plum curculio. The purpose should be to coat thoroughly the foliage, twigs, and young fruit to insure to the fullest extent possible the poisoning of the beetles. The same precautions as to poisoning the foliage, fruit, and buds are also essential in making the second application, as the beetles are still very numerous, feeding and ovipositing freely. (See Table II.) This is also the most important application for the prevention of scab infection, which is prevented only by thoroughly coating the young fruits. In subsequent applications the efforts should be directed more to coating the fruit with the spray to protect it from brown-rot infection, especially as it begins to ripen.

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[1] Reported in the Journal of Economic Entomology, vol. 2, p. 130

The schedule of applications (pp. 38–40) takes account of the ripening period of the principal commercial varieties of peaches. Applications made later than a month or six weeks before picking time are likely to result in the fruit being more or less spotted with the spray when harvested, somewhat marring its appearance for market purposes. This danger can be largely avoided by using nozzles which throw a mistlike spray, coating the fruit with very fine dots rather than with large blotches.

DIRECTIONS FOR THE PREPARATION OF SELF-BOILED LIME-SULPHUR WASH.

The standard self-boiled lime-sulphur mixture is composed of 8 pounds of fresh stone lime and 8 pounds of sulphur to 50 gallons of water. In mild cases of brown-rot and scab a weaker mixture containing 6 pounds of each ingredient to 50 gallons of water may be used with satisfactory results. The materials cost so little, however, that one should not economize in this direction where a valuable fruit crop is at stake. Any finely powdered sulphur (flowers, flour, or "commercial ground" sulphur) may be used in the preparation of the mixture.

In order to secure the best action from the lime, the mixture should be prepared in rather large quantities, at least enough for 200 gallons of spray, using 32 pounds of lime and 32 pounds of sulphur. The lime should be placed in a barrel and enough water (about 6 gallons) poured on to almost cover it. As soon as the lime begins to slake the sulphur should be added, after first running it through a sieve to break up the lumps, if any are present. The mixture should be constantly stirred and more water (3 or 4 gallons) added as needed to form at first a thick paste and then gradually a thin paste. The lime will supply enough heat to boil the mixture several minutes. As soon as it is well slaked water should be added to cool the mixture and prevent further cooking. It is then ready to be strained into the spray tank, diluted, and applied.

The stage at which cold water should be poured on to stop the cooking varies with different limes. Some limes are so sluggish in slaking that it is difficult to obtain enough heat from them to cook the mixture at all, while other limes become intensely hot on slaking, and care must be taken not to allow the boiling to proceed too far. If the mixture is allowed to remain hot for 15 or 20 minutes after the slaking is completed, the sulphur gradually goes into solution, combining with the lime to form sulphids, which are injurious to peach foliage. It is therefore very important, especially with hot lime, to cool the mixture quickly by adding a few buckets of water as soon as the lumps of lime have slaked down. The intense heat, violent boiling, and constant stirring result in a uniform mixture of finely divided sulphur and lime, with only a very small percentage of the sulphur in solution. It should be strained to take out the coarse particles of lime, but the sulphur should be carefully worked through the strainer.

DIRECTIONS FOR USING ARSENATE OF LEAD.

Many experiments have shown that well-made arsenate of lead is much the safest of all available arsenicals for use on the peach. Arsenate of lead is to be found on the market both as a powder and as a putty-like paste, which latter must be worked free in water before it is added to the lime-sulphur mixture. The paste form of the poison is largely used at the rate of about 2 pounds to each 50 gallons of the lime-sulphur wash and is added, after it has been well worked free in water, to the lime-sulphur spray previously prepared. As there are numerous brands of arsenate of lead upon the market, the grower should be careful to purchase from reliable firms. A decided change in color will result when the arsenate of lead is added to the lime-sulphur mixture, due to certain chemical changes which, in the experience of the writers, do not injuriously affect the fungicidal and insecticidal properties of the spray or result in injury to the foliage.

In large spraying operations it will be more convenient to prepare in advance a stock mixture of arsenate of lead, as follows: Place 100 pounds of arsenate of lead in a barrel, with sufficient water to work into a thin paste, diluting finally with water to exactly 25 gallons. When thoroughly stirred, each gallon of the stock solution will thus contain 4 pounds of arsenate of lead, the amount necessary for 100 gallons of spray. In smaller spraying operations the proper quantity of arsenate of lead may be weighed out as needed, and thinned with water. In all cases the arsenate of lead solution should be strained before or as it is poured into the spray tank. The necessary care should be exercised to keep the poison out of the reach of domestic and other animals.

DANGER OF INJURY FROM SPRAYING.

As stated elsewhere in this bulletin, the foliage of the peach is extremely sensitive to injury from such sprays as Bordeaux mixture and arsenicals, such as Paris green, arsenate of lead, etc. This sensitiveness has been the sole reason why it has been impracticable to spray peach orchards with fungicides and insecticides such as Bordeaux mixture or Paris green, as has for years been the custom in the case of apples, grapes, and other deciduous fruits.

Of the various arsenicals available for use, well-made arsenate of lead has proved to be the safest. Shortly after the development of this comparatively new insecticide, it was at once extensively experimented with on peaches by numerous entomologists and it was tried to a limited extent by peach growers. A single application of arsenate of lead in water did not result in injury so important as to prevent its use. However, when two or three applications were made, as is necessary in the control of the curculio, serious shot-holing and falling of the leaves and even burning of the fruit resulted, the latter, in extreme cases, falling to the ground. The use of lime with arsenate of lead lessened the danger of injury considerably, but used even in this way for two or three treatments, especially under certain weather conditions, resulted in extensive injury to foliage and fruit.

When it was established that the self-boiled lime-sulphur wash was an effective fungicide and entirely safe as a spray for the peach, one of the interesting questions presented was whether arsenate of lead might be safely used with it to effect a combination spray for both insects and diseases. While on chemical grounds it appeared that the addition of arsenate of lead to the self-boiled lime-sulphur mixture would result in an important decomposition of the spray and greatly add to its probable injurious character, in practice the combined spray was found to be entirely safe. Observations extending over three seasons have failed to show any serious injury resulting from the use of this spray, even when as many as three applications were made. Thus, in the test of numerous brands of arsenate of lead at Barnesville, Ga., during 1910, carried out by Mr. E. W. Scott, of the Bureau of Entomology, peach trees were given three thorough applications: (1) With arsenate of lead in limewater at the rate of 2 pounds to 50 gallons, and (2) in the self-boiled lime-sulphur wash used at the same strength. In all cases very serious injury resulted to fruit and foliage on the plats sprayed with the arsenate of lead in limewater, whereas there was no discernible injury on the plats treated with arsenate of lead in the self-boiled lime-sulphur wash. It is not understood why the arsenate of lead apparently loses its injurious properties when used in the self-boiled lime-sulphur wash, though its safe employment in this way is most fortunate.

In the schedule of applications only two arsenate of lead treatments are recommended, as these will measurably control the curculio and a third treatment would considerably increase the danger of injury. Where the curculio is very destructive, however, the grower should use his judgment as to whether a third application of the poison would be advantageous.

The effect of the arsenate of lead upon the fruit is to increase its color notably. This increase in color from two applications in self-boiled lime-sulphur wash improves the appearance of the fruit. Three or even two applications of the poison alone or in limewater, however, result in a very excessive reddening, especially on the side exposed to the sun, on which later may appear brown, sunken spots of variable size, accompanied with more or less extensive cracking of the skin. This condition of the fruit is shown in figure 13.

The self-boiled lime-sulphur mixture when properly prepared according to directions does not injure the fruit or foliage, but if allowed to remain hot in concentrated form before dilution enough sulphur may go into solution to produce injury to the foliage. Users of this spray should therefore follow carefully the directions given for its preparation, bearing in mind that a good mechanical mixture of the sulphur and lime suspended in water and only slightly combined is desired rather than to dissolve any considerable quantity of the sulphur.

During the application of the spray, it is very important that the mixture be kept well agitated to insure its uniform distribution. As both the self-boiled lime-sulphur wash and the arsenate of lead quickly settle when the spray is left undisturbed, an excessive amount may be applied to some trees, while others receive an insufficient quantity. While most spraying equipments are supplied with adequate agitating apparatus, the orchardist should assure himself that the spray is being properly stirred in the tank during its application. Under conditions of imperfect agitation and consequent settling, the ingredients of the spray may be applied so strong that serious injury will result. This has been observed to be the case, especially following the employment of compressed-air sprayers with inefficient agitators.

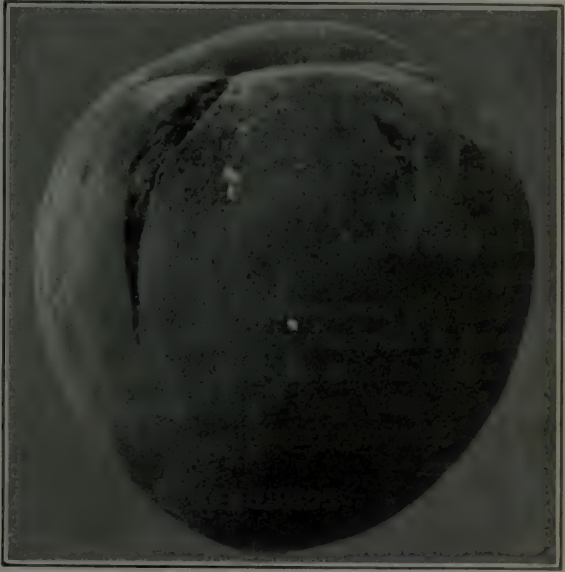

FIG. 13.—Elberta peach sprayed three times with arsenate of lead, showing the browning and cracking effect of the poison.

COST OF TREATMENT.

The cost of the combined treatment for the control of brown-rot, scab, and curculio is insignificant when compared with the resulting benefits. The trees at Baldwin, Ga., were sprayed with a good hand outfit, and 3 men were able to spray 1,000 trees a day. With labor at 75 cents a day (the wages paid in that section), arsenate of lead at 10 cents a pound, sulphur at 2½ cents a pound, and lime at $1.10 a barrel, the cost for three treatments was $27.60 a thousand, or a little less than 3 cents a tree. At Fort Valley, Ga., a gasoline-power sprayer was used. The trees there were larger and the water was not so convenient, making the cost somewhat higher than at Baldwin. In this case the cost of three treatments was $32 a thousand, or a little more than 3 cents a tree. Where wages are higher the cost will be somewhat greater. For three treatments, the first with arsenate of lead alone, the second with self-boiled lime-sulphur and arsenate of lead, and the third with self-boiled lime-sulphur alone, the cost will range from 3 to 5 cents per tree, depending upon the labor conditions, the size of the trees, the convenience of the water supply, and the equipment used. For average-sized 7-year-old trees, as a rule 1 gallon of spray per tree will be required for each application. In the first application not quite so much will be required, owing to scant foliage at that time, while a little more will be required for the second treatment. The third application should be lighter than the second, using finer nozzles so as to avoid staining the fruit with blotches of lime.

From the experience of the writers it seems safe to conclude that in most of the peach orchards of the eastern United States an increase per tree of at least one-half bushel of good merchantable fruit, worth about 50 cents, may be obtained from spraying at a cost of 3 to 5 cents. Spraying, therefore, is the most profitable of all the orchard operations.

SCHEDULE OF APPLICATIONS.

Most of the peach orchards in the eastern half of the United States should be given the combined treatment for brown-rot, scab, and curculio. This is particularly true of the southern orchards, where all these troubles are prevalent. In some of the more northern orchards the curculio is not very troublesome, but as a rule it will probably pay to add the arsenate of lead in at least the first lime-sulphur application.

The self-boiled lime-sulphur mixture referred to in the following outlines of treatment should be made of a strength of 8 pounds of lime and 8 pounds of sulphur to each 50 gallons of water, and the arsenate of lead should be used at the rate of 2 pounds to each 50 gallons of the mixture or of water. When the poison is used in water there should be added the milk of lime made from slaking 2 to 3 pounds of good stone lime. When used in the lime-sulphur mixture additional lime will not be necessary.

Midseason varieties.—The midseason varieties of peaches, such as Reeves, Belle, Early Crawford, Elberta, Late Crawford, Chairs, Fox, and Beers Smock, should be sprayed as follows:

(1) With arsenate of lead alone, about 10 days after the petals fall, or at the time the calyxes are shedding. (Fig. 14.)

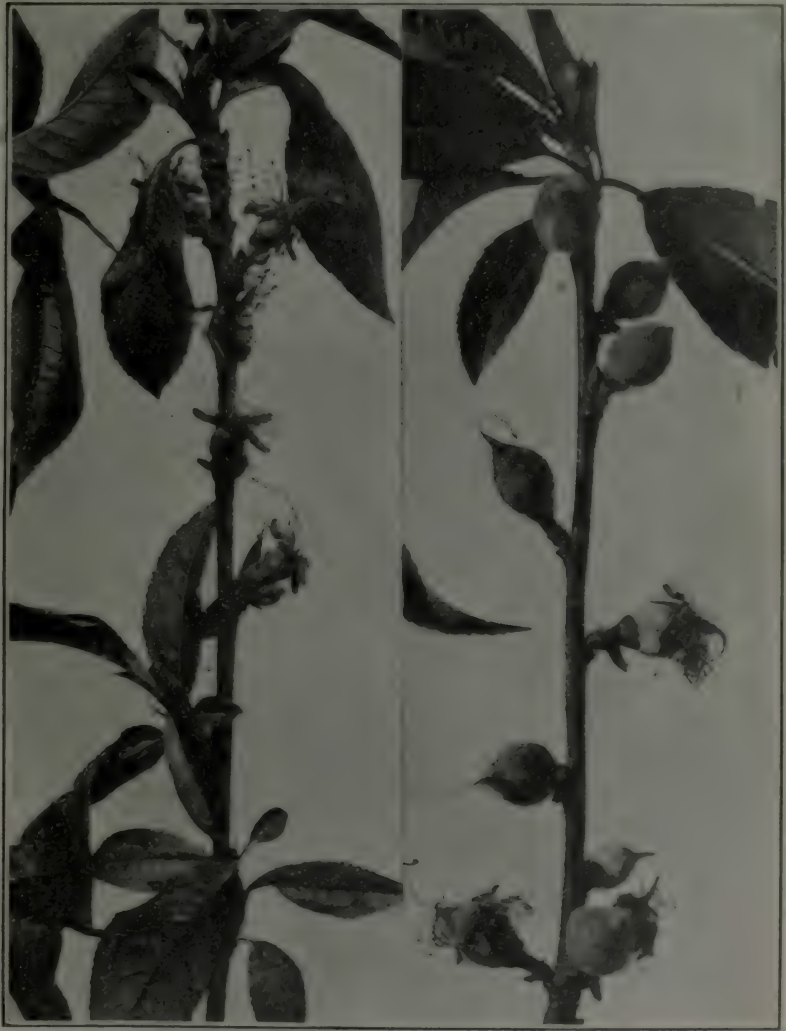

FIG. 14.—Young peaches, showing the earliest and latest stages at which the first arsenate of lead treatment should be made.

(2) With self-boiled lime-sulphur and arsenate of lead, two weeks later, or four to five weeks after the petals have been shed.

(3) With self-boiled lime-sulphur alone, four to five weeks before the fruit ripens.

Late varieties.—The Salway, Heath, Bilyeu, and varieties with a similar ripening period should be given the same treatment prescribed for midseason varieties, with an additional treatment of self-boiled lime-sulphur alone, to be applied three or four weeks after the second application.

Early varieties.—The Greensboro, Carman, Hiley, Mountain Rose, and varieties having the same ripening period should receive the first and second applications prescribed for midseason varieties.

Where the curculio is not particularly bad, as in Connecticut, western New York, and Michigan, the first treatment, which is for this insect only, may be omitted. Also for numerous orchards throughout the Middle States where the insect, especially in the younger orchards, is not yet very troublesome, orchardists should use their judgment as to whether the first application may be safely omitted. Where peach scab is the chief trouble, and brown-rot and curculio are of only minor importance, as may be the case in some of the Allegheny Mountain districts, satisfactory results may be had from two applications, namely, the first with self-boiled lime-sulphur and arsenate of lead four to five weeks after the petals fall, and the second treatment of the above schedule with self-boiled lime-sulphur alone three to four weeks later. These two treatments, if thoroughly applied, will control the scab and brown-rot, especially on the early and midseason varieties, and will materially reduce curculio injuries. Even one application of the combined spray made about five weeks after the petals fall would pay well, although this is recommended only for conditions where it is not feasible to do more.

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Issued May 2, 1911.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 441.

LESPEDEZA, OR JAPAN CLOVER.

BY

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AND

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WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., February 14, 1911.

Sir: I have the honor to transmit herewith, and to recommend for publication as a Farmers' Bulletin, the accompanying manuscript, entitled "Lespedeza, or Japan Clover."

The lespedeza plant, which was accidentally introduced into the United States about sixty years ago, has now spread over all the Southern States and northward into Kansas and Pennsylvania. Over all of its area it is highly esteemed as a constituent of pastures, and in the lower Mississippi Valley grows so luxuriantly that splendid crops of hay are cut.

This bulletin is based on manuscripts prepared independently by Mr. A. D. McNair, of the Office of Farm Management, and Mr. W. B. Mercier, of the Office of Farmers' Cooperative Demonstration Work, both based on experience and study of the plant in the lower Mississippi Valley. These two papers have been combined and edited by Mr. C. V. Piper, Agrostologist in Charge of Forage-Crop Investigations, and some material concerning the behavior and value of lespedeza in other States has been added.

On account of the high value of lespedeza in a comparatively limited region, a great deal of interest in the crop has been excited over the whole area where it grows. This bulletin is designed to meet the increasing demands for information, and it is also hoped that it will be of much practical value in the region where the crop is at present most utilized.

Respectfully,

Wm. A. Taylor,
Acting Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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LESPEDEZA, OR JAPAN CLOVER.

INTRODUCTION.

Lespedeza, or Japan clover (*Lespedeza striata*) (figs. 1 and 2), is a native of eastern Asia that was first found in this country in central Georgia in 1846. It has spread since then so that it now covers more or less abundantly the whole area from central New Jersey westward to central Kansas and southward to the Gulf of Mexico (fig. 3). There is reason to believe that it has now reached nearly the limits over which it will spread naturally. A common belief exists in the South that the plant was first introduced during the Civil War. This is erroneous, though it is doubtless true that the spread of the plant was greatly increased during that struggle by the movements of cavalry.

Lespedeza is a summer annual that begins its growth in the middle part of spring but does not reach maturity until September and October. It is sometimes confused with the yellow-flowered hop clovers, but is readily distinguished by its purplish blossoms, which do not appear till August or later, while the hop clovers bloom early.

Over most of its area lespedeza grows only 4 to 6 inches high, and there has thus arisen the common idea that it is adapted only to grazing. Under favorable conditions, however, especially in the lower Mississippi Valley on certain soils, the plants grow commonly to a height of 12 inches, frequently reaching 18 inches, and in exceptional cases 24 to 30 inches. Where the stand is very thin the plants have a prostrate habit, but where it is thick they grow upright, and the yield of hay from such plants is large, often exceeding 2 tons per acre and exceptionally reaching 3 or even 4 tons per acre (fig. 4).

Under such conditions lespedeza is a crop of very high value, which has become more and more appreciated in late years, so that many farmers now employ it in regular rotations. It is not improbable that a wider knowledge of the merits of the crop will cause it to be more generally cultivated and perhaps over a considerably wider area.

Lespedeza grows during practically the same season as certain other leguminous forage crops; i. e., cowpeas, soy beans, velvet beans, and beggarweed. Its desirability in any particular place will depend upon its ability to compete with the above-mentioned crops.

LESPEDEZA FOR PASTURAGE.

The value of lespedeza for grazing was early recognized, and it has been looked upon with high favor as a constituent of pastures. It grows in all types of soil, even the poorest, and thus furnishes a considerable quantity of forage in pine barrens and in gravelly soils where scarcely any other plants grow. The natural spread of the plant has made it a constituent of practically every pasture in the region covered by its distribution. Everywhere it is valued for its ability to grow in very poor soils, either in fields or in open woodlands, and to withstand severe drought. Its value depends upon its palatability, its high feeding value, which approaches alfalfa, and its ability to thrive under all sorts of conditions, and thus to furnish pasturage in the summer and fall till killed by frosts. It will withstand almost any amount of grazing. In no sense can it be considered a weed, as it quickly succumbs to cultivation. Like other clovers, it sometimes causes horses and mules to "slobber."

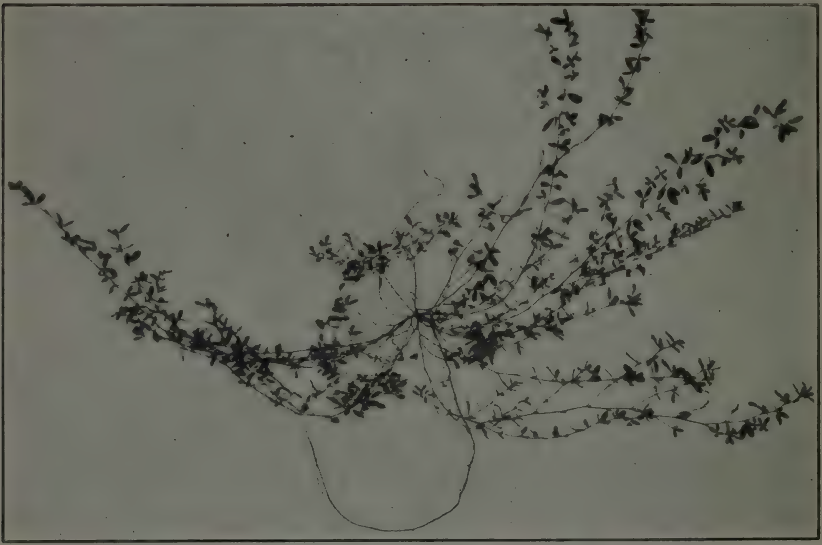

FIG. 1.—A plant of lespedeza, showing the character of growth where the stand is thin.

The best pastures in the South are perhaps those which in summer consist of Bermuda grass and lespedeza. With the addition of redtop and bur clover, sweet clover, or hairy vetch, such pastures can be grazed the year around, the Bermuda grass and lespedeza growing in summer, the others mostly in winter. In poor or mixed pastures lespedeza commonly holds its own with broom sedge and similar coarse grasses and unquestionably adds materially to the grazing. It is perhaps no exaggeration to state that it has increased the carrying capacity of practically all the pasture land of the South by at least 25 per cent.

Lespedeza reseeds itself so readily that it is rarely necessary to sow it on pasture lands. This, however, is often desirable in a new pasture or in old pastures where for any reason the plant does not occur. It occasionally happens that the lespedeza seeds sprout unusually early owing to favorable weather, and the plants are killed by late frosts. Such pastures may be reseeded simply by scattering the seed over the top of the sod, but with better results after scratching with a harrow. New pastures should be seeded early in the spring, preferably in February in the southern tier of States and later northward. Seedings up to the middle of April in Louisiana

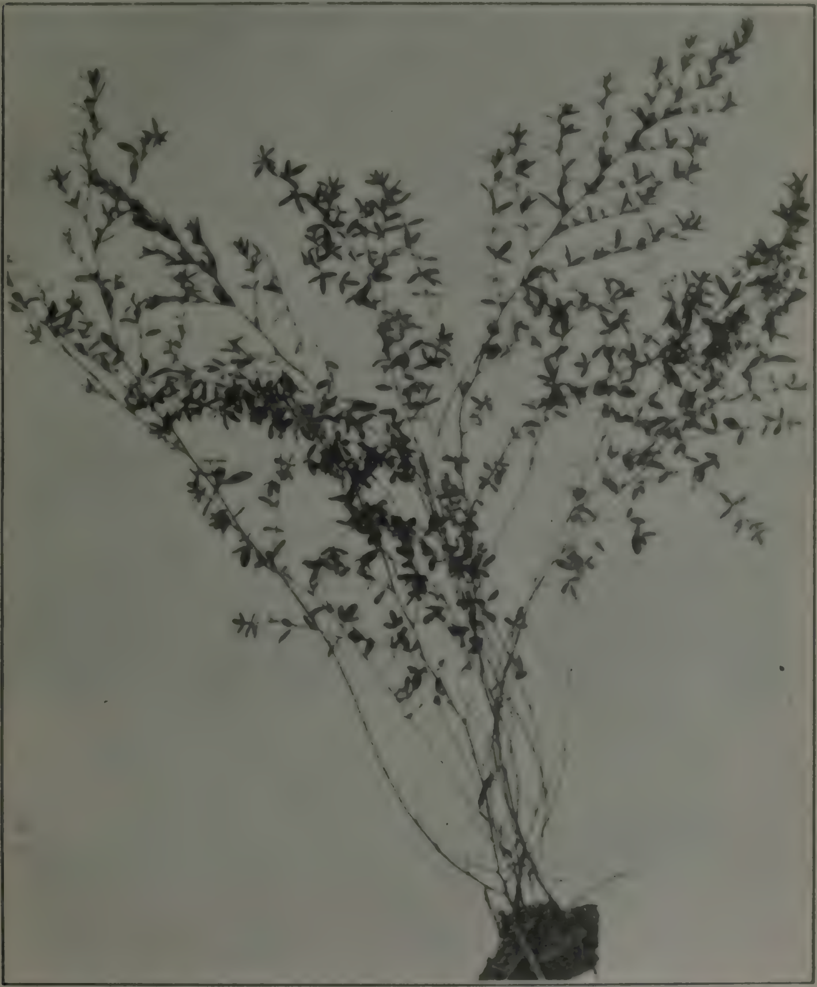

FIG. 2.—A plant of lespedeza, showing the upright growth made where the stand is reasonably thick.

have given satisfactory results. An excellent stand is frequently secured simply by spreading the manure from stock fed on ripe hay or by allowing the animals to run freely from one pasture to another when the seeds are ripe. Sometimes hay with ripe seeds is scattered over the high points of pastures in which lespedeza is desired, the winds and rains spreading the seeds over much of the field. The seed will live over in the soil at least one year, so that fairly good stands may be expected after only one season of clean tillage. It is not wise, however, to rely wholly on such volunteer growth.

LESPEDEZA AS A FARM CROP.

Until comparatively recent years lespedeza was utilized mainly as a pasture crop, though in certain sections the taller growths were cut for hay. At the present time, however, it is becoming more and more used as a regular farm crop, the seed being sown when the crop is desired, according to the particular rotation employed. On favorable soils or with good treatment it gives high yields, making it a most profitable crop. The experiences of farmers, as well as experiments, have developed many different methods or rotations in which the crop can be employed. The most important of these are here discussed.

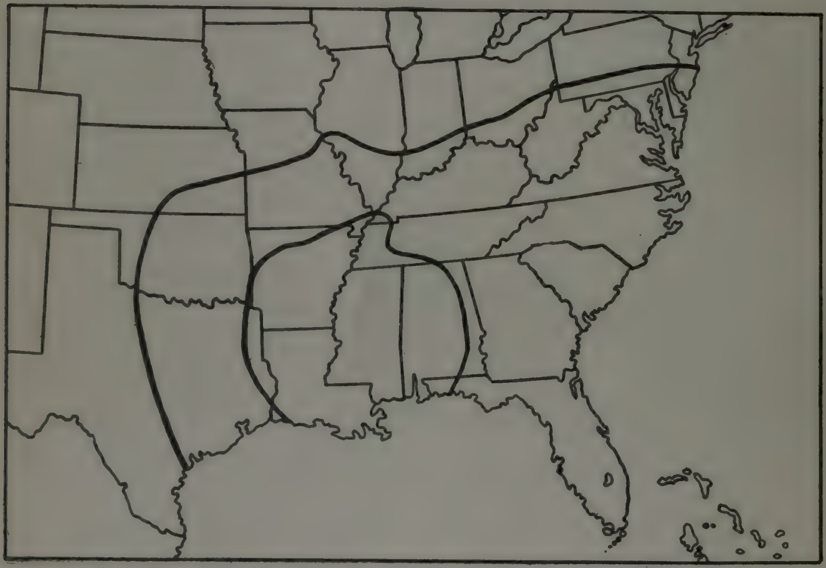

FIG. 3.—Map of the southeastern part of the United States showing the approximate area over which lespedeza is now naturalized and within which (the smaller area) it is cut for hay.

Lespedeza, like other legumes, extracts nitrogen from the air through the bacterial tubercles or "nitrogen balls" on the roots.

Owing, perhaps, to the occurrence of numerous American species of this plant, lespedeza is nearly always naturally inoculated. It is advisable, however, when planting it for the first time in new soils to provide inoculation either by the use of pure cultures or by the soil-transfer method.[1]

BERMUDA GRASS AND LESPEDEZA.

Lespedeza is very commonly a constituent of Bermuda-grass meadows, and probably the first lespedeza cut for hay was in such a mixture. The admixture of lespedeza in Bermuda grass is in every way desirable. While it does not add, perhaps, to the yield of hay, it materially improves the quality. Such a meadow may persist for years, but eventually the ingress of weeds reduces its value. It is seldom necessary to sow the lespedeza, as it usually finds its way into the Bermuda-grass meadow quickly.

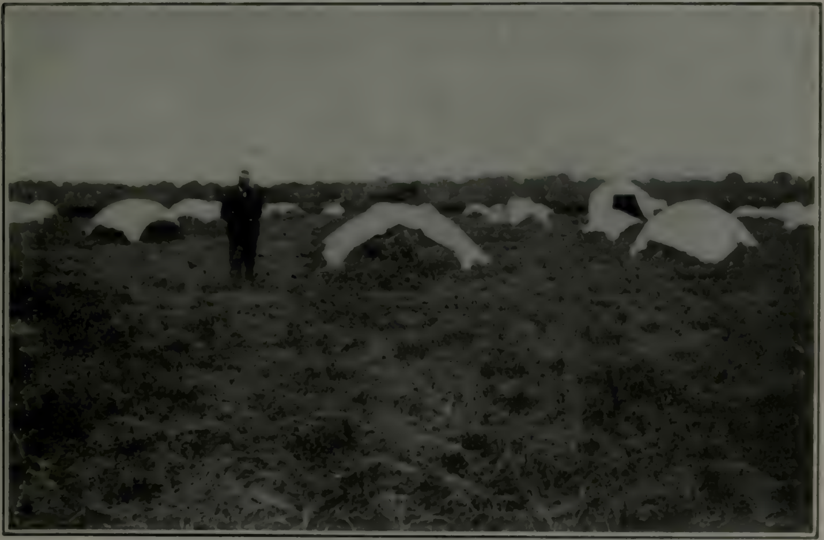

FIG. 4.—A corner of a lespedeza hayfield at Monroe, La., showing haycocks with canvas covers. This farm produced 300 tons of hay from 115 acres in 1907.

REDTOP AND LESPEDEZA.

Redtop makes an excellent combination with lespedeza in the same field, yielding a crop of each every year. The redtop is preferably sown in the fall and the lespedeza on the same land the following February. The redtop is cut about June 1, at which time the clover is only 3 to 4 inches high. Following the cutting of redtop, the lespedeza occupies the ground exclusively until September or October.

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[1] See Circular No. 63 of the Bureau of Plant Industry, entitled "Methods of Legume Inoculation."

when it is likewise cut for hay. The redtop, being perennial, comes again the following year, while the lespedeza reseeds itself. Each crop reproduces indefinitely with proper management or until broom sedge creeps in, which occurs usually about the third year. It then becomes necessary to break the land and plant something else.

In some of the valleys of western Arkansas only the redtop is sown, the lespedeza growing as a volunteer crop. Grown in this way, the lespedeza is free from mixture at cutting time, and is of high quality, at least as long as the broom sedge does not appear.

The cutting of the redtop should not be delayed too long, as it results in an inferior quality of hay, and is apt to decrease the yield of lespedeza hay.

The crops of redtop and lespedeza succeed best on bottom lands where there is plenty of moisture and even where it is too wet for corn and cotton.

The combination of redtop and lespedeza is different from that of Bermuda grass and lespedeza previously mentioned, for the reason that the Bermuda grass and lespedeza have the same season of growth, and the hay produced is a mixture of the two, whereas the redtop-lespedeza combination yields first a cutting of redtop and later in the season a cutting of practically pure lespedeza hay.

OATS AND LESPEDEZA.

The combination of oats and lespedeza is quite commonly employed by progressive farmers. The seed of lespedeza is sometimes sown with the grain in the fall, but it is preferable to wait until February or March. In sowing, 15 pounds of seed per acre is sufficient, though 25 pounds is often sown. It is advisable to harrow the seed in lightly after sowing. With proper handling, such a rotation can be continued several years without resowing the lespedeza. For this purpose good results may be obtained on some soils by disking the lespedeza stubble rather than plowing.

For example, Mr. Guy P. Stubbs, of Ouachita Parish, Louisiana, had a large acreage of lespedeza in 1907, which was harvested, and the land plowed and sowed to oats in October and November. The oats were cut about June 1, 1908, giving a yield of 35 bushels per acre. When the oats were cut, the volunteer lespedeza was about 4 inches high, and this, when harvested, yielded 2 tons of cured hay per acre. Assuming the oats to be worth 60 cents a bushel and the hay $14 a ton, there was produced $21 worth of oats and $28 worth of hay, a total value of $49 per acre.

Perhaps in no case does this rotation represent the entire system of farming on any particular farm, but it is a feature of many farms. It is fairly common in parts of Louisiana and Mississippi, but is not permanent on any one farm. Sooner or later, corn or cotton or both occupy the land for a season. This is due to the fact that it is a rotation without an intertilled crop and permits the multiplication of weeds, particularly broom sedge and ragweed.

CORN, OATS, AND LESPEDEZA.

A three-year rotation of corn, oats, and lespedeza has much to commend it. Corn is harvested the first year, oats and lespedeza the second year, and the lespedeza alone the third year. Sometimes the lespedeza is allowed to reseed itself and is harvested the fourth year. Such a system is used by Mr. Jacob Grewe, of Ouachita Parish, Louisiana. In the fall of 1908 Mr. Grewe sowed 55 acres of Monroe sandy loam soil[1] to winter oats, and in February, 1909, sowed lespedeza in the oats. The oats were cut about June 1, yielding 1,400 bushels, or about 25½ bushels per acre. Mr. Grewe states that his second year's crop of lespedeza is usually better than the first, and yields 2 to 3 tons per acre on good land.

This three-year rotation is really part of a four-year rotation in which cotton should be included, especially in those sections not yet infested by the boll weevil. In Mr. Grewe's case he omitted the cotton, not because it did not fit into his system, but because the boll weevil had done so much damage that he was content to drop cotton and plant something else.

This rotation permits the farming of much more land than corn and cotton alone. The additional work of harvesting oats is quickly performed and the extra work of harvesting lespedeza comes in the fall when it does not interfere with other work. If there is any interference, the cutting of lespedeza can be delayed without serious injury, provided only that it is cut before it is injured by frost.

This sequence of crops, moreover, is well calculated both to improve the land and to increase yields. Lespedeza is comparable with cowpeas as a fertilizer and occupies the land two seasons out of three. This rotation also checks soil erosion, because the fields are covered with oats one winter and with lespedeza stubble two winters out of the three.

COTTON, CORN, OATS, AND LESPEDEZA.

A rotation of cotton, corn, oats, and lespedeza, which is followed by Mr. Kenneth McKay, of East Feliciana Parish, Louisiana, may be either a four-year or a five-year rotation, depending on whether the lespedeza stands two years or three years. It calls for more comment and discussion than the preceding systems, because it embraces the leading crops of the South. Any cropping system designed for the cotton belt and embracing lespedeza should, if possible, include the two crops which are most important in that region, viz, cotton and corn. As a four-year rotation this is outlined in detail in the following table:

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[1] For a description of Monroe sandy loam, see the Fifth Annual Report of the Bureau of Soils, 1903, pp. 419–438.

TABLE I.—*A four-year rotation of cotton, corn, oats, and lespedeza.*

Year.	First field.	Second field.	Third field.	Fourth field.
First	Cotton	Corn (with cowpeas between the rows).	Oats, followed by lespedeza.	Lespedeza.
Second	Corn (with cowpeas between the rows).	Oats, followed by lespedeza.	Lespedeza	Cotton.
Third	Oats, followed by lespedeza.	Lespedeza	Cotton	Corn (with cowpeas between the rows).
Fourth	Lespedeza	Cotton	Corn (with cowpeas between the rows).	Oats, followed by lespedeza.

Provision is here made for five crops in four years (six crops, if the cowpeas are counted), as follows:

One money crop—cotton.

Two cereals for money or feed—corn and oats.

Two hay crops for money or feed—lespedeza.

A pasture or fertilizing crop—cowpeas.

Lespedeza is also a fertilizing crop. Thus three years out of four the land is provided with crops that provide humus and nitrogen.

In this system only half the land is in intertilled crops, corn and cotton, the other half being devoted to oats and lespedeza. This has an important bearing on the acreage that can be farmed. Where cotton and corn are the only crops or almost the only crops grown it means a small acreage for each man and for each horse, because all or nearly all the land that is cropped must be intertilled.

It is entirely practicable, if desired, to abandon the lespedeza at the end of the third year and plant cotton the fourth year, making it a three-year rotation.

The leading advantages of the rotation just described over the plan of growing cotton and corn exclusively are as follows: (1) It enables the farmer to farm more acres per man and per horse; (2) it enriches the soil, thereby increasing the yield per acre of every crop; and (3) as a result of the foregoing advantages the farmer's income is greatly increased.

It is interesting to compare the four-year rotation just outlined with that well-known three-year rotation of cotton, corn with cowpeas, and oats followed by cowpeas. The rotations are similar. Substitute lespedeza for cowpeas in the third year, and let the lespedeza perpetuate itself so that it can be harvested the fourth year, and we have exactly the four-year rotation here presented.

One notable advantage of the lespedeza over the cowpeas is that the lespedeza involves no labor immediately after oat harvest, whereas the oat stubble must be either plowed or disked to prepare for planting cowpeas. The period of oat harvest (late May and early June) is a time when farmers are busy cultivating their crops of cotton and corn, and are particularly crowded if the season is wet; hence, there is little time to prepare land and plant cowpeas. But if lespedeza is sown on the oat field in February it will usually be about 3 inches high at oat harvest.

LESPEDEZA IN DAIRY-FARM ROTATIONS.

An excellent rotation for a dairy farm in which lespedeza can be used for hay and also for pasture is as follows:

TABLE II.—*A four-year rotation for a dairy farm, with lespedeza for hay and pasture.*

Year.	First field.	Second field.	Third field.	Fourth field.
First	Corn (with cowpeas between the rows).	Soy beans[1]	Oats Lespedeza	Lespedeza.
Second	Soy beans or Spanish peanuts.[1]	Oats Lespedeza	Lespedeza	Corn (with cowpeas between the rows).
Third	Oats Lespedeza	Lespedeza	Corn (with cowpeas between the rows).	Soy beans or Spanish peanuts.[1]
Fourth	Lespedeza	Corn (with cowpeas between the rows.)	Soy beans or Spanish peanuts.[1]	Oats. Lespedeza.

[1] Peanuts may be substituted for soy beans in this rotation, in which case the peanuts may be used as cow feed or hog feed, or both, or may be sold as a money crop.

A farm of 60 acres divided into 4 fields of 15 acres each and cropped according to this plan would furnish all the hay and grain needed for 3 work horses, 16 cows in milk, and enough hogs to make 1,000 pounds of live pork, and would supply 5 to 10 tons of surplus hay for sale. This is on the assumption of a yield of 40 bushels of corn per acre, 20 bushels of soy beans and 1 ton of soy-bean hay per acre, 40 bushels of oats per acre, and 2¼ tons of lespedeza hay per acre.

Such yields could not be looked for the first season unless the land was very good, but the practice of this rotation, together with the manure produced on such a farm, would soon bring it to this standard with only a moderate use of commercial fertilizers. In addition to the hay and grain produced, this farm would furnish half the pasture needed for the live stock. The other half might be obtained from a permanent Bermuda-grass pasture, which could be provided separate and apart from the rotation outlined.

For pasture purposes, a rotation of crops embracing lespedeza is superior to one embracing only the larger annual legumes, like cowpeas, peanuts, and soy beans. Alfalfa is more productive, but is scarcely suitable for short rotations and is not so generally adapted to southern soils. Soy beans, peanuts, and cowpeas fit nicely into various rotations, but they are not pasture plants except for hogs, and even then principally for their grain. Lespedeza, however, is good for both hay and pasture, and its pasture season includes the months from May to October, inclusive. It can be grazed all the season and come again the next year; it can be grazed until June, and will then make hay in the fall; or it can be cut in August and grazed the rest of the season and still make seed to renew the stand.

HARVESTING LESPEDEZA.

The date of harvesting lespedeza will depend upon whether the crop is for hay or seed or both. The plants usually begin to blossom in late summer, and it is the common practice to cut for hay in October, after some of the seeds are mature. Where it is desirable to have the crop reseed itself, some of the seeds must be allowed to mature, which can be accomplished in several ways: (1) The crop may be cut early, not later than the time the first blossoms appear, in which case a new growth starts from the stubble and matures seed before frost; (2) the crop may be cut after some of the seeds have matured, enough being shattered in mowing and handling to seed the land for the succeeding crop; and (3) the mower may leave narrow strips of the plants uncut at each round.

Isolated plants of lespedeza have nearly prostrate, spreading branches which are too near the ground to be mowed but which bear seed abundantly. When, however, the plants are tall and crowded, they grow perfectly erect with nearly erect branches and no seeds are produced near the ground. It is quite easy to tell from the appearance of a field mown before any seed is ripe whether a succeeding crop may be expected. If there are prostrate branches in the stubble, the number of these will determine whether enough seed will be produced to renew the stand.

YIELDS OF HAY.

Lespedeza is commonly harvested with an ordinary mowing machine, and it is usually not profitable to cut for hay unless the height is 8 inches or more, for if shorter the hay is very difficult to rake.

The lespedeza plant contains less water than any other cultivated legume, so that it is not difficult to cure. It cures more easily and quickly than red clover, alfalfa, or cowpeas, though not as quickly as timothy. It must not, of course, be stored or baled too soon, else it will heat and mold like other hay plants.

In good haying weather mowing can begin as soon as the dew is off, and the lespedeza can be raked into windrows the same day. It should stand in the windrows at least a day and then be put in small cocks until cured.

On the lands best adapted to the growing of lespedeza, yields of 1½ to 2½ tons per acre are common. Such land normally yields 30 to 35 bushels of oats per acre. Where lespedeza grows with its accustomed thickness to the height of 8 or 9 inches, a yield of a ton to the acre may be expected, allowing 2 inches for the stubble. A height of 12 to 14 inches will give approximately 2 tons per acre, and at its extreme height of 24 to 30 inches maximum yields of 4 tons or even more have been reported.

HARVESTING FOR SEED.

Seed of lespedeza is at present harvested mostly in Louisiana and to a less extent in Mississippi. For this purpose the crop is mown before frost, when the larger part of the seeds have matured but the plants are still green. It should be raked immediately after mowing, or when it is wet with dew, so as to prevent shattering and to permit it to cure entirely in the windrows. More commonly, however, the newly cut lespedeza is put into small cocks called "pats." These pats are so small that they will dry out even if rained on. A few growers are using bunching attachments to the mowing machines which automatically leave the crop in small bunches. When thoroughly dry the crop is put in the barn or stack, or even thrashed directly from the field. For hauling, the wagon should have tight wagon frames or else have sheets spread over the bottom so as to catch the loose seed. Much care should also be taken in unloading from the wagons, as otherwise much seed will be lost.

For thrashing the straw should be thoroughly dry, as otherwise much trouble is experienced on account of the mucilaginous nature of the plants. After thrashing, the seed should be spread out rather thinly on the floor to dry. Much depth should be avoided, as otherwise the seeds are likely to heat and become moldy. For commercial purposes the seed should be run through a fanning machine for recleaning, but for farm purposes may be used as it comes from the thrasher. Good seed recleaned but unhulled weighs about 25 pounds to the bushel. Practically all the seed on the market is unhulled. (See fig. 5.)

For home use usually sufficient seed can be obtained from the bottom of the hay mow, especially if the hay is cut after a considerable portion of the seeds have ripened.

A cheap and easy method of saving seed for home use, though some growers use the same method in saving seed for the market, is what is known as the pan method. A galvanized iron pan is attached to the rear of the cutter bar of the mowing machine and extends about

2½ feet back, being as long as the bar itself. Small iron rods extend across the pan in the direction of the line of motion. A man walks behind and as the lespedeza falls on the iron rods he rakes it off, letting it fall on the ground. In this operation considerable seed shatters into the pan and is removed when the pan is full. This is afterwards cleaned with a fanning mill. (See fig. 6.)

It is usually best to utilize the comparatively short crop grown on hill lands for gathering seed, as there is much less straw to thrash and the seed yield is usually as great or greater. Furthermore, where the plants are tall the large yield of hay makes it more valuable than the seed crop would be.

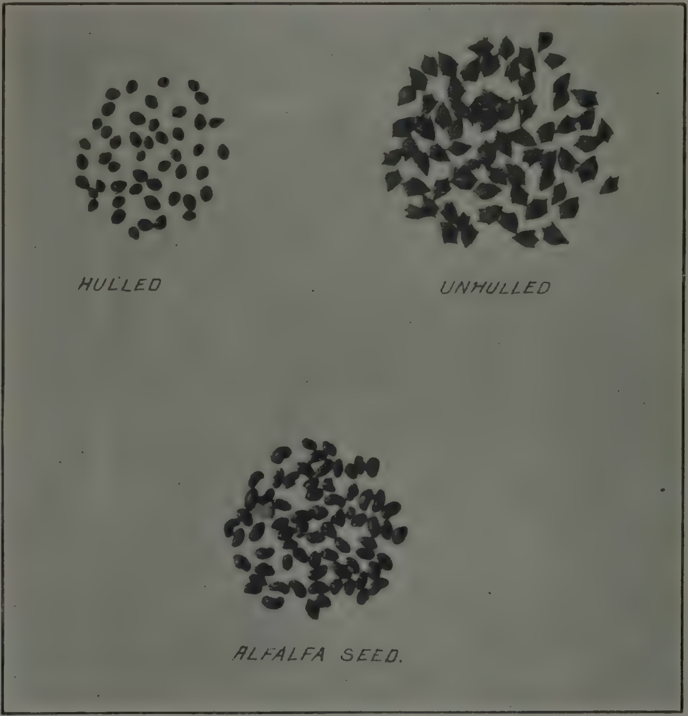

Fig. 5.—Seed of lespedeza and alfalfa, showing relative sizes.

The yield of seed varies from 5 to 12 bushels per acre and commonly commands a price of $3 to $3.50 per bushel. At the present time the demand is greater than the supply. The straw from thrashed lespedeza has considerable value as feed and it is not uncommonly baled for this purpose.

POSSIBILITY OF EXTENDING THE LESPEDEZA-PRODUCING AREA.

Figure 3, page 8, shows the approximate area over which lespedeza now occurs naturally and also the area within which it is cut for hay. It is a matter both of interest and of importance to determine whether this area can be extended to embrace at least all the cotton belt. The eastern half of the cotton belt differs from the central part scarcely at all in climate, but does differ greatly in soils. Lespedeza grows especially well in the lower Mississippi Valley on the black lands and on soils composed largely of silt. On the black soils alfalfa often thrives luxuriantly. But even on lands that will not grow alfalfa well, lespedeza produces fine crops. On the other hand, in eastern Alabama, Georgia, South Carolina, and northern Florida lespedeza seems rarely to grow tall enough to justify cutting for hay. Whether the value of the crop would justify special treatment, as liming and manuring, in localities where other summer legumes like cowpeas, beggarweed, soy beans, and velvet beans are being grown successfully is doubtful. The question requires experimental investigation.

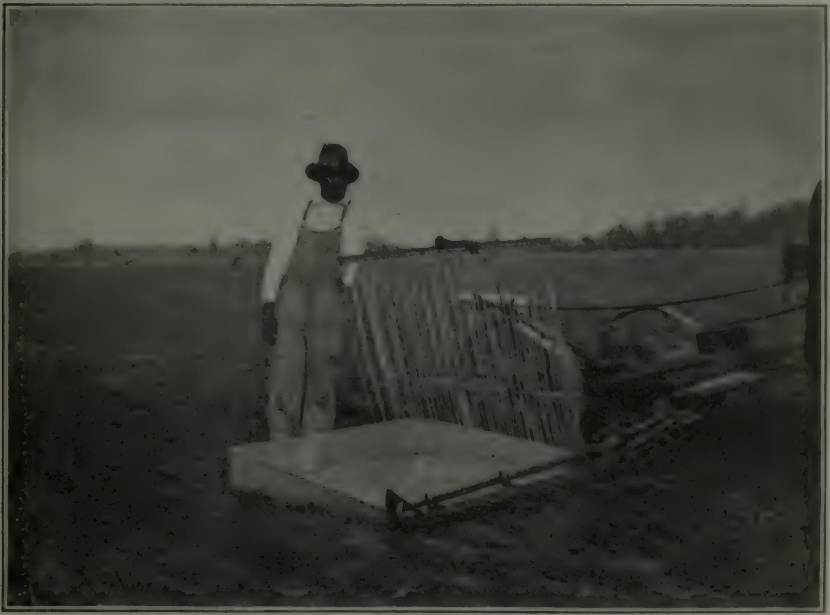

FIG. 6.—Lespedeza pan, with top raised to show wires or rods between which the seed falls into the pan when the crop is harvested.

Northward it is hardly likely that lespedeza will ever be anything more than a grazing plant, the season being too short to allow the luxuriant growth attained in Louisiana and Mississippi.

One other factor may be important. Lespedeza is a variable plant, sufficiently so to justify the separation of the various types in the hope that the best may grow large enough to yield hay crops over a wider area than is now suited to the plant.

Pending further investigations it should be borne in mind that the use of lespedeza as a hay crop is recommended only in the region indicated on the map (fig. 3), and that even within the area there shown the plant does not grow tall on the poorer soils, although it responds remarkably well to both manure and lime.

SUMMARY.

(1) Lespedeza, or Japan clover, introduced into the United States from Asia about sixty years ago, now occurs from New Jersey westward to Kansas and southward to the Gulf of Mexico.

(2) Lespedeza is an annual and is esteemed as a constituent of pastures, being especially valuable for this purpose on poor or thin soils where other plants do not thrive. It withstands drought well and matures seed under very severe grazing; hence, it is rarely necessary to resow it on pasture lands.

(3) Artificial inoculation with nitrogen-fixing bacteria is necessary only when the seed is first sown on new land.

(4) At the present time lespedeza can be recommended as a hay crop only on the fertile lands of the lower Mississippi Valley and on certain silt soils, where it frequently attains a height of from 12 to 30 inches and yields from two to four tons of hay per acre. Only one cutting of hay can be obtained in a season.

(5) In other regions lespedeza seldom grows more than 4 to 6 inches high, and under such conditions it is unlikely that the plant will be profitable for other than grazing purposes.

(6) With Bermuda grass lespedeza produces excellent pastures in the South, materially improving the quality of the hay without perhaps increasing its quantity.

(7) Under conditions where it thrives, lespedeza has increased the carrying capacity of permanent pasture lands of the South by at least 25 per cent.

(8) The lespedeza plant has a lower moisture content than any other cultivated legume and can be cured more rapidly than red clover, alfalfa, or cowpeas, though not as quickly as timothy.

(9) The present demand for the seed of lespedeza is greater than the supply. Under favorable conditions the yields are from 5 to 12 bushels of seed per acre, which command a price of $3 to $3.50 a bushel.

(10) In the lower Mississippi Valley the plant is being increasingly sown in regular rotation with excellent results.

(11) Alfalfa is more productive than lespedeza, but is scarcely suitable for short rotations and is not so generally adapted to southern soils.

(12) For pasture purposes in the lower Mississippi Valley a rotation embracing lespedeza is superior to one involving only the larger annual legumes, such as cowpeas, peanuts, and soy beans, lespedeza being excellent for both pasturage and hay, whereas the other legumes mentioned are not properly pasture crops.

[A list giving the titles of all Farmers' Bulletins available for distribution will be sent free upon application to a Member of Congress or the Secretary of Agriculture.]

Issued May 6, 1911.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 442.

THE TREATMENT OF BEE DISEASES.

BY

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WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., February 24, 1911.

Sir: I have the honor to transmit herewith a manuscript entitled "The Treatment of Bee Diseases," by E. F. Phillips, Ph. D., in charge of bee culture in this bureau. In the preparation of this paper, which is intended to supersede Circular 79, of this bureau, the aim has been to give briefly the information needed by the beekeeper who has disease in his apiary. No discussion of the cause or distribution of these diseases has been included. I recommend the publication of this paper as a Farmers' Bulletin.

Respectfully,

L. O. Howard,
Entomologist and Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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THE TREATMENT OF BEE DISEASES.

INTRODUCTION.

The diseases which attack the honey bee may be divided into two classes, namely, those affecting the brood and those to which the adult bees are subject. The diseases of adult bees have not been investigated sufficiently to make it possible at the present time to recommend methods for their treatment. In the present bulletin, therefore, only a brief statement concerning these diseases will be made, mainly for the purpose of indicating the present state of knowledge on these subjects. Concerning the diseases of the brood more is known, and this is particularly fortunate since they are far more destructive in American apiaries than are the diseases of the adult bees.

The causes of bee diseases will not be discussed here. For information on this phase of the subject the reader is referred to other publications of the Bureau of Entomology, which are listed at the end of this bulletin. The aim of this bulletin is to give information that can be used by the practical beekeeper in combating bee diseases.

THE BROOD DISEASES OF BEES.

The brood diseases of the honey bee are already widely distributed in the United States and seem to be spreading rather rapidly. The loss to the beekeepers of the country, owing to the actual death of colonies by disease, is estimated conservatively at $1.000.000 annually. This does not include the loss of crops, resulting from the destruction of colonies, or the discouragement to the beekeeper which often causes him to give up the business. A considerable part of this loss is due to the indifference of the beekeepers to these diseases and a lack of knowledge concerning them.

It frequently happens that colonies in an apiary become infected before the owner realizes that disease is present. He may erroneously attribute the losses observed to some other cause. In this way the disease gets a start which makes eradication difficult when once the cause of the loss has been discovered. In view of the widespread distribution of these diseases, it is most desirable that all beekeepers learn to distinguish the diseases when they appear and to know how to keep them under control.

It is often a matter of surprise to beekeepers to learn that bees are subject to disease. The most frequent source of confusion is the placing of the blame for loss of colonies on some cause other than disease. The poorer class of beekeepers attribute their losses simply to "bad luck," but even well-informed beekeepers err in this matter.

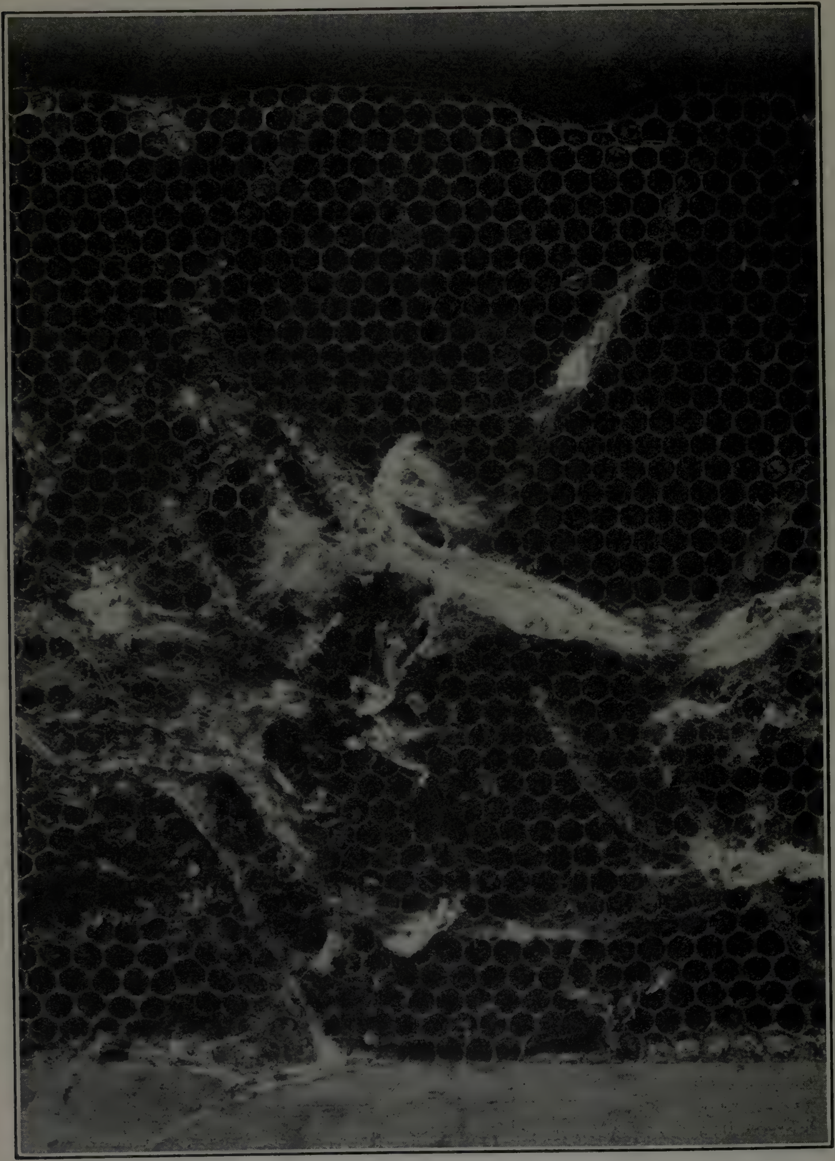


FIG. 1.—Work of the larger wax moth in a brood comb. (Original.)

The wax moths (see fig. 1) are most frequently blamed for the death of colonies, whereas they do no damage to strong, healthy colonies, properly cared for, but enter only when the colony is weakened by queenlessness, lack of stores, disease, or some other cause. In the majority of the reports of wax-moth depredations received by this department which can be investigated it is found that the trouble is actually an outbreak of a brood disease.

The spraying of fruit trees while in bloom is possibly injurious to bees, and there exists among beekeepers a strong feeling against the practice. Since no entomologist now recommends that fruit trees be sprayed during the blooming period, this is probably rarely done by progressive fruit growers. However, it is frequently reported by beekeepers that they are losing bees by poisoning due to spraying. A number of cases of the death of colonies, reported as caused by poisoning due to spraying while trees were in bloom, have been found to be in reality outbreaks of European foul brood, which is particularly prevalent in the spring and early summer.

Other circumstances to which is often attributed the death of brood or of the colony are chilling, fumes from coke ovens, and malicious poisoning. The wise attitude on the part of the beekeeper is first to suspect diseases as being the cause of any losses which he may sustain, and to be sure that there is no infectious disease present before looking elsewhere for a cause.

NATURE OF THE DISEASES.

There are two recognized infectious diseases of the brood of bees, now known as American foul brood and European foul brood. Both diseases weaken colonies by reducing the number of emerging bees needed to replace the old adult bees which die from natural or other causes. In neither case are adult bees affected, so far as known. The means used by the beekeeper in deciding which disease is present is the difference in the appearance of the larvæ dead of the two diseases. That the diseases are entirely distinct can not now be doubted, since they show certain differences in the age of the larvæ affected, in their response to treatment, and in the appearance of the dead larvæ. This is made still more certain by a study of the bacteria present in the dead larvæ. Reports are sometimes received that a colony is infected with both diseases at the same time. While this is possible, it is not by any means the rule, and such cases are usually not authentically reported. There is no evidence that chilled or starved brood develops into an infectious disease or that dead brood favors the development of a disease.

NAMES OF THE DISEASES.

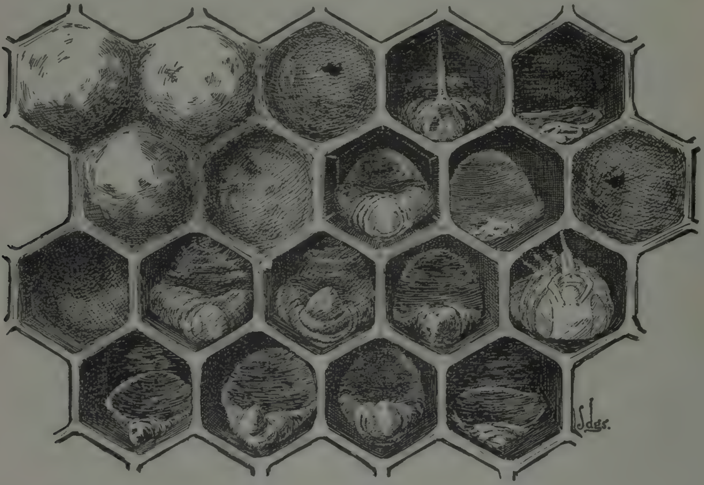
The names American foul brood and European foul brood were applied to these diseases by the Bureau of Entomology, of this department, to clear up the confusion in names which formerly existed. By retaining the words "foul brood" in each name the disease-inspection laws then in force could be interpreted as applying to both diseases. These names were in no way intended to designate geographical distribution, since both diseases did exist and do now exist in both Europe and America, but were chosen primarily because they were convenient and easily remembered names. Their only significance is in indicating where the diseases were first seriously investigated. It was particularly desirable to change the name of the disease now known as European foul brood, since "black brood" entirely fails to be descriptive and is misleading.

SYMPTOMS.

The presence of a particular disease in a colony of bees can be ascertained most reliably by a bacteriological examination, since the symptoms are somewhat variable. It is possible, however, to describe the usual manifestations of the diseases, and the usual differences, so that the beekeeper can in most cases tell which disease is present.

American Foul Brood.

American foul brood is frequently called simply "foul brood." It usually shows itself in the larva just about the time that the larva fills the cell and after it has ceased feeding and has begun pupation.



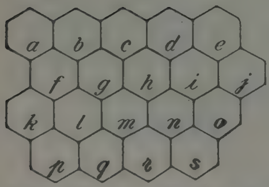


Fig. 2.—American foul brood: *a, b, f,* normal sealed cells; *c, j,* sunken cappings, showing perforations; *g,* sunken capping not perforated; *h, l, m, n, q, r,* larvæ affected by disease; *e, i, p, s,* scales formed from dried-down larvæ; *d, o,* pupæ affected by disease. Three times natural size. (Original.)

At this time it is sealed over in the comb (fig. 2, *a, b, f*). The first indication of the infection is a slight brownish discoloration and the loss of the well-rounded appearance of the normal larva (fig. 2, *l*). At this stage the disease is not usually recognized by the beekeeper. The larva gradually sinks down in the cell and becomes darker in color (fig. 2, *h*, *m*), and the posterior end lies against the bottom of the cell. Frequently the segmentation of the larva is clearly marked. By the time it has partially dried down and has became quite dark brown (coffee colored) the most typical characteristic of this disease manifests itself. If a match stick or tooth-pick is inserted into the decaying mass and withdrawn the larval remains adhere to it and are drawn out in a thread (fig. 3), which sometimes extends for several inches before breaking. This ropiness is the chief characteristic used by the beekeeper in diagnosing this disease. The larva continues to dry down and gradually loses its ropiness until it finally becomes merely a scale on the lower side wall and base of the cell (fig. 2, *e*, *p*, *s*). The scale formed by the dried-down larva adheres tightly to the cell and can be removed with difficulty from the cell wall. The scales can best be observed when the comb is held with the top inclined toward the observer so that a bright light strikes the lower side wall (fig. 4).

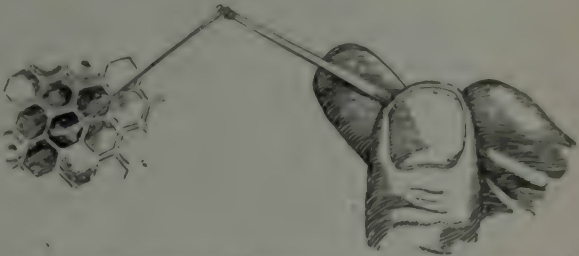


FIG. 3.—The ropiness of American foul brood. (Original.)

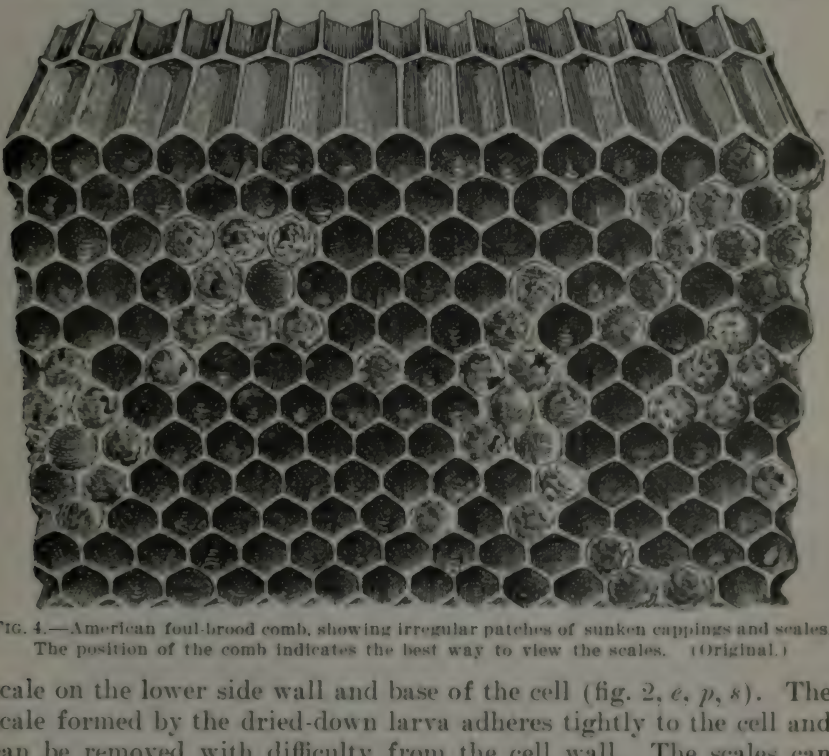


FIG. 4.—American foul-brood comb, showing irregular patches of sunken cappings and scales. The position of the comb indicates the best way to view the scales. (Original.)

A very characteristic and usually penetrating odor is often noticeable in the decaying larvæ. This can perhaps best be likened to the odor of heated glue.

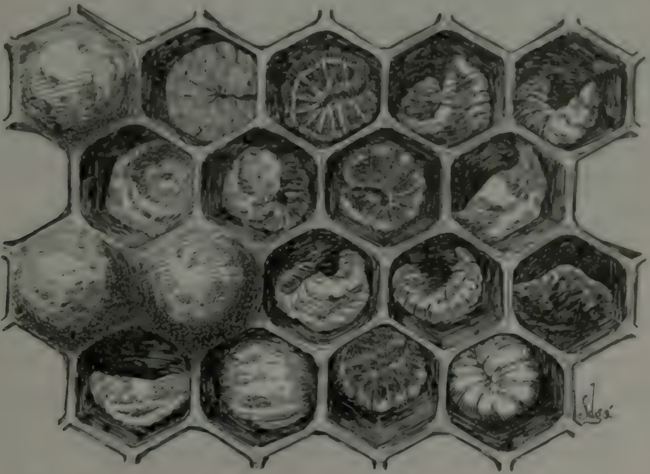
The majority of the larvæ which die of this disease are attacked after being sealed in the cells. The cappings are often entirely removed by the bees, but when they are left they usually become sunken (fig. 2, *g*, *c*, *j*) and frequently perforated (fig. 2, *c*, *j*). As the healthy brood emerges the comb shows the scattered sunken cappings covering dead larvæ (fig. 4), giving it a characteristic appearance.

Pupæ also may die of this disease, in which case they, too, dry down (fig. 2, *o*, *d*), become ropy, and have the characteristic odor and color. The tongue frequently adheres to the upper side wall and often remains there even after the pupa has dried down to a scale. Younger unsealed larvæ are sometimes affected. Usually the disease attacks only worker brood, but occasional cases are found in which queen and drone brood are diseased. It is not certain that race of bees, season, or climate have any effect on the virulence of this disease, except that in warmer climates, where the breeding season is prolonged, the rapidity of devastation is more marked.

European Foul Brood.

European foul brood was formerly called " black brood " or " New York bee disease." The name " black brood " was a poor one, for the color of the dead brood is rarely black or even very dark brown. European foul brood usually attacks the larva at an earlier stage of its development than American foul brood and while it is still curled up at the base of the cell (fig. 5, *r*). A small percentage of larvæ dies after capping, but sometimes quite young larvæ are attacked (fig. 5, *e*, *m*). Sunken and perforated cappings are sometimes observed just as in American foul brood (fig. 2, *c*, *g*, *j*). The earliest indication of the disease is a slight yellow or gray discoloration and uneasy movement of the larva in the cell. The larva loses its well-rounded, opaque appearance and becomes slightly translucent, so that the tracheæ may become prominent (fig. 5, *b*), giving the larvæ a clearly segmented appearance. The larva is usually flattened against the base of the cell, but may turn so that the ends of the larva are to the rear of the cell (fig. 5, *p*), or may fall away from the base (fig. 5, *e*, *g*, *l*). Later the color changes to a decided yellow or gray and the translucency is lost (fig. 5, *q*, *h*). The yellow color may be taken as the chief characteristic of this disease. The dead larva appears as a moist, somewhat collapsed mass, giving the appearance of being melted. When the remains have become almost dry (fig. 5, *c*) the tracheæ sometimes become conspicuous again, this time by retaining their shape, while the rest of the body content dries around them. Finally all that is left of the larva is a grayish-brown scale against the base of the cell (fig. 5, *f*, *h*), or a shapeless mass on the lower side wall if the larva did not retain its normal position (fig. 5, *n*, *o*). Very few scales are black. The scales are not adhesive, but are easily removed, and the bees carry out a great many in their efforts to clean house.

Decaying larvæ which have died of this disease are usually not ropy as in American foul brood, but a slight ropiness is sometimes observed. There is usually little odor in European foul brood, but sometimes a sour odor is present, which reminds one of yeast fermentation. This disease attacks drone and queen larvæ[1] almost as quickly as those of the workers.



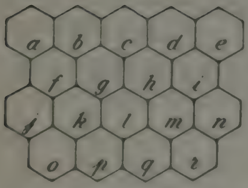


Fig. 5.—European foul brood: *a*, *j*, *k*, normal sealed cells; *b*, *c*, *d*, *e*, *g*, *i*, *l*, *m*, *p*, *q*, larvæ affected by disease; *r*, narmal larva at age attacked by disease; *f*, *h*, *n*, *o*, dried-down larvæ or scales. Three times natural size. (Original.)

European foul brood is more destructive during the spring and early summer than at other times, often entirely disappearing during late summer and autumn, or during a heavy honey flow. Italian bees seem to be better able to resist the ravages of this disease than any other race. The disease at times spreads with startling rapidity and is most destructive. Where it is prevalent a considerably larger percentage of colonies is affected than is usual for American foul brood. This disease is very variable in its symptoms and other manifestations and is often a puzzle to the beekeeper.

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[1] The tendency of this disease to attack queen larvæ is a serious drawback in treatment. Frequently the bees of a diseased colony attempt to supersede their queen, but the larvæ in the queen cells often die, leaving the colony hopelessly queenless. The colony is thus depleted very rapidly.

The So-Called "Pickle Brood."

In addition to the two infectious diseases just described, brood dead from other causes is often observed. The most common disease of this kind is what is known among beekeepers as "pickle brood." This name is seemingly applied to a great many different appearances and nothing is known of the cause or methods of spread. The most typical form kills the larva when it has extended itself in the cell. The larva usually lies on its back with the head turned upward. The color varies, but is frequently light yellow or brown, and the head is often almost black. The body is swollen and the contents watery, and the head may be quite hard. There is no ropiness. In case the larvæ are sealed before dying the cappings are usually normal. The name usually applied to this condition was unwisely chosen, and for the present and until more is known concerning the disease it is spoken of as the "so-called pickle brood."

This trouble does not appear to be infectious and is usually not serious, except that in the aggregate it may cause loss by weakening colonies. No treatment is necessary, as the trouble usually soon disappears. The most serious aspect of this disease is that it is often mistaken for one of the infectious diseases, and the colony is needlessly treated.

Brood dead of other causes.

Many different external factors may cause brood to die. If brood is killed by chilling in the spring or fall, or by overheating in extremely hot weather, or in shipping colonies of bees, or by starvation, the loss is often mistakenly attributed to an infectious disease. Such dead brood is soon removed by the bees. When the cause is removed the trouble then soon disappears. When a considerable quantity of brood is killed a disagreeable odor is usually present.

"Bald-headed brood."

It sometimes happens that unsealed or only partially sealed pupæ, known as "bald-headed brood," are observed in the hive, and frequently beginners mistake such a condition for disease. The partially built capping is often mistaken for the punctured capping of American foul brood. If, on examination, the pupæ are normal no fear need be entertained.

METHODS OF SPREAD.

Both American foul brood and European foul brood spread from colony to colony and from apiary to apiary in much the same way. The common means of carrying the virus is in honey which has become contaminated. The disease may be carried when bees rob a hive in which a colony has died of disease or may be transmitted by the use of honey from diseased colonies for feeding bees. It is not always necessary that bees be intentionally fed for them to get disease from contaminated honey. Discarded honey receptacles which have contained honey from a contaminated colony, if not thoroughly cleaned, may contain enough honey to carry disease to a healthy apiary. This may occur in the vicinity of bakeries or confectionery shops, or may even occur when empty honey bottles are thrown out from private houses. It is also possible to introduce disease into a colony in introducing queen bees purchased from a distance, probably due to the use of contaminated honey in making the candy to supply the queen cages.

Precautionary Measures.

In combating diseases it is much better to prevent disease from getting a foothold than it is to eradicate it after it has begun its work. All beekeepers, wherever located, should practice the following precautionary measures:

(1) If a colony becomes weak from any cause, or if disease is suspected, contract the entrance to prevent robbing, and if robbing is imminent close the entrance entirely.

(2) *Never feed honey purchased on the open market.* In case of doubt as to the source of honey feed sugar sirup.

(3) If within the range of possibility, see that no honey that comes from diseased apiaries is sold in the neighborhood. This may sometimes be accomplished by cultivating the home market so that there will be no incentive for bringing in other honey.

(4) In introducing purchased queens, transfer them to clean cages provided with candy known to be free from contamination, and destroy the old cage, candy, and accompanying workers. Of course, if it is certain that the queen comes from a healthy apiary this is not necessary.

(5) Colonies of bees should never be purchased unless it is certain that they are free from disease.

(6) The purchase of old combs or second-hand supplies is dangerous, unless it is certain that they came from healthy apiaries.

TREATMENT FOR BOTH INFECTIOUS DISEASES.

The treatment of an infectious bee disease consists primarily in the elimination or removal of the cause of the disease. It is definitely known that American foul brood is caused by a bacillus named *Bacillus larvæ*. In treating this disease, therefore, the aim of the manipulation is to remove or destroy all of the bacteria of this species. It should be remembered that the effort is not to save the larvæ that are already dead or dying, but to stop the further devastation of the disease by removing all material capable of transmitting the cause of the trouble.

The cause of European foul brood is not definitely known, but the same principles of treatment doubtless apply in this disease also. In all of the operations great pains should be taken not to spread the disease through carelessness. After handling a diseased colony the hands of the operator should be washed with water to remove any honey that may be on them. It does not pay to treat colonies that are considerably weakened by disease. In case there are several such colonies they should be united to form strong, vigorous colonies before or during treatment.

In discussing treatment it is assumed that hives with movable frames are in use. Box hives are a menace in regions where disease is present. These may be treated for disease by drumming the colony into another box and then hiving it like a swarm in a hive, but box hives are not profitable and are especially to be condemned where disease is present on account of the difficulty in inspecting and treating.

Shaking Treatment.

The shaking treatment consists essentially in the removal of all infected material from the colony, and in compelling the colony to take a fresh start by building new combs and gathering fresh stores. This is done by shaking the bees from the old combs into a clean hive on clean frames.

Time of treatment.—The shaking treatment should be given during a flow of honey, so that other bees in the apiary will not be inclined to rob. If this is not possible the operation may be performed under a tent made of mosquito netting. The best time is during the middle of a clear day when a large number of bees are in the field. It is sometimes recommended that shaking be done in the evening, but this is impossible if many colonies are to be treated. The colony can be handled more quickly when the field force is out of the hive.

Preparation.—All implements that will be needed, such as queen and drone trap, hive tool, and lighted smoker, should be in readiness before the operation is begun. A complete clean hive with frames is provided, as well as a tightly closed hive body in which to put the contaminated combs after shaking. An extra hive cover or some similar apparatus should be provided to serve as a runway for the bees as they enter the new hive. The new frames should contain strips of comb foundation from one-fourth to 1 inch wide. Full sheets are not desirable, and if combs built on full sheets of foundation are desired they may be built later.

Operation.—The old hive containing the diseased colony (fig. 6, *A*) is now lifted to one side out of the flight of returning field bees and the clean hive (*B*) set exactly in its place. The cover (*G*) is now taken off and a few frames (*E*) removed from the center of the hive. If unspaced frames are used, those remaining in the hive should be pushed tightly to either side of the hive, thus making a barrier beyond which the bees can not crawl as they move to the top of the hive after shaking. This largely prevents them from getting on the outside of the hive. If self-spacing frames are used, a couple of thin boards laid on the top bars on either side will accomplish the same result. The runway (*D*) is put in place in front of the entrance. The old hive is now opened for the first time. The frames are removed one at a time, lowered part way into the new hive, and with a quick downward shake the bees are dislodged. The frames are then put into the extra hive body (*C*) and immediately covered to prevent robbing. After all the frames are shaken the bees remaining on the sides of the old hive (*A*) are shaken out.

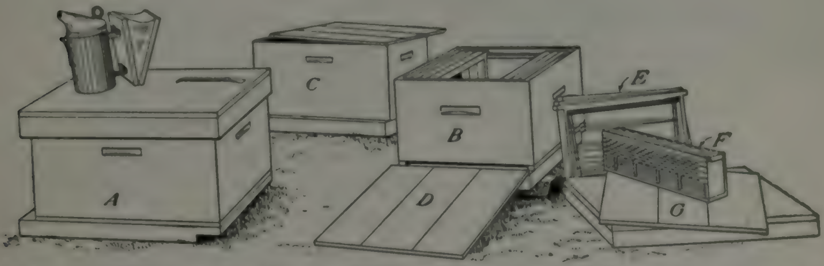

Fig. 6.—Apparatus for the shaking treatment: *A*, Hive containing diseased colony (formerly in position of *B*); *B*, clean hive; *C*, empty hive to receive combs after shaking; *D*, hive cover used as runway; *E*, frames removed from *B* to give room for shaking; *F*, queen and drone trap; *G*, cover for clean hive, *B*. (Original.)

If honey is coming in freely, so that thin honey is shaken out of the combs, cover the runway (*D*) with newspapers and shake the bees in front of the new hive (*B*), leaving all frames in place and the cover on. After the operation the soiled newspapers should be destroyed. In shaking in front of the entrance the first one or two frames should be so shaken that the bees are thrown against the entrance, where they can locate the hive quickly. They then fan their wings and the others follow them into the hive. If this is not done the bees may wander about and get under the hive or in some other undesirable place.

After the bees are mostly in the new hive a queen and drone trap (*F*) or a strip of perforated zinc is placed over the entrance to prevent the colony from deserting the hive. The queen can not pass through the openings in the perforated zinc and the workers will not leave without her. By the time that new combs are built and new brood is ready to be fed, any contaminated honey carried by the bees into their new hive will have been consumed and the disease will rarely reappear. If it should, a repetition of the treatment will be necessary.

Saving the healthy brood.—The old combs are now quickly removed. If several colonies are being treated at one time it may pay to stack several hive bodies containing contaminated combs over a weak diseased colony to allow most of the healthy brood to emerge, thereby strengthening the weak colony. After 10 or 12 days this colony is treated in turn and all the combs rendered into wax. If only one or two colonies in a large apiary are being treated it will not pay to do this.

Saving the wax.—Any but a very small apiary should have included in its equipment a wax press for removing wax from old combs. After the contaminated frames are taken to the honey house the combs should be kept carefully covered, so that no bees can reach them until the wax can be rendered. This should not be delayed very long or the combs may be ruined by wax moths. The slumgum or refuse remaining after the wax is removed should be burned. Contaminated combs should not be put into a solar wax extractor for fear of spreading the disease. The wax from contaminated combs may safely be used for the manufacture of comb foundation.

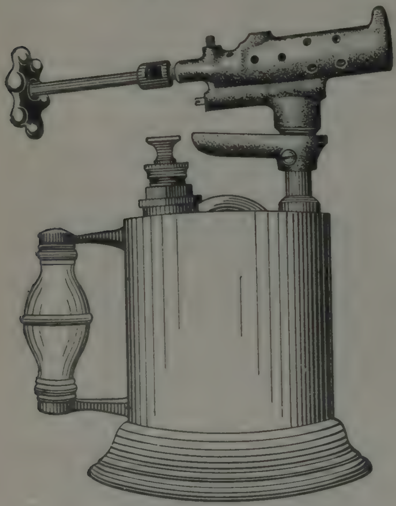

FIG. 7.—Gasoline torch. (Original.)

Cleaning the hive.—The hive which has contained the diseased colony should be thoroughly cleaned of all wax and honey, and it is desirable that it be carefully disinfected by burning out the inside with a gasoline blue-flame torch (fig. 7). If this piece of apparatus is not available several hive bodies may be piled together on a hive bottom and some gasoline or kerosene poured on the sides and on some straw or excelsior at the bottom. This is then ignited and after burning for a few seconds a close-fitting hive cover is placed on top of the pile to extinguish the flames. The inside of the hive bodies should be charred to a light brown. The careful cleaning and disinfection of frames always costs considerably more in labor than new frames would cost, but these also may be carefully cleaned and used again. Frames may be cleaned by boiling in water for about half an hour, but this frequently causes them to warp badly. The disinfection of hives and frames with chemicals is not recommended, as the ordinary strengths used are valueless for the purpose.

Disposal of the honey.—If there is a considerable quantity of honey in the contaminated combs it may be extracted. This honey is not safe to feed to bees without boiling, but it is absolutely safe for human consumption. If there is a comparatively small quantity it may be consumed in the beekeeper's family, care being taken that none of it is placed so that the bees can ever get it.

To put such honey on the market is contrary to law in some States. There is always danger that an emptied receptacle will be thrown out where bees can have access to it, thus causing a new outbreak of disease. It can be safely used for feeding to bees, provided it is diluted with at least an equal volume of water to prevent burning, and boiled in a closed vessel for not less than one-half hour, counting from the time that the diluted honey first boils vigorously. The honey will not be sterilized if it is heated in a vessel set inside of another containing boiling water. Boiled honey can not be sold as honey. It is good only as a food for bees, and even then should never be used for winter stores, as it will probably cause dysentery.

The second shake.—Some beekeepers prefer to shake the bees first onto frames containing strips of foundation as above described, and in four days to shake the colony a second time onto full sheets of foundation, destroying all comb built after the first treatment. This insures better combs than the use of strips of foundation, but is a severe drain on the strength of the colony. Since it is desirable to have combs built on full sheets, the best policy is to replace any irregular combs with full sheets of foundation or good combs later in the season.

The cost of shaking.—If the treatment just described is given at the beginning of a good honey flow, it is practically equivalent to artificial swarming and results in an actual increase in the surplus honey, especially in the case of comb-honey production. The wax rendered from the combs will sell for enough to pay for the foundation used if full sheets of foundation are employed. Since a colony so treated actually appears to work with greater vigor than a colony not so manipulated, the cost of treatment is small. If treatment must be given at some other time, so that the colony must be fed, the cost is materially increased. In feeding, it is best to use sugar sirup, or honey that is known to have come from healthy colonies.

Treatment with Bee Escape.

As a substitute for the shaking treatment just described, the bees may be removed from their old combs by means of a bee escape. The old hive is moved to one side and in its place is set a clean hive with clean frames and foundation. The queen is at once transferred to the new hive and the field bees fly there on their return from the field. The infected hive is now placed on top of or close beside the clean hive and a bee escape placed over the entrance, so that the younger bees and those which later emerge from the cells may leave the contaminated hive but can not return. They therefore join the colony in the new hive. If desired, the infected hive may be placed above the clean hive and a tin tube about 1 inch in diameter placed from the old entrance so that the lower end is just above the open entrance of the new hive. The bees follow down this tube and on their return enter the new hive. When all of the healthy brood has emerged from the infected combs the old hive is removed. This treatment induces less excitement in the apiary and is preferred by many experienced beekeepers. Care should be taken that the old hive is absolutely tight to prevent robbing. The old hive and its contents of honey and wax are treated as indicated under the shaking treatment.

Fall Treatment.

If it is necessary to treat a colony so late in the fall that it would be impossible for the bees to prepare for winter, the treatment may be modified by shaking the bees onto combs entirely full of honey so that there is no place for any brood to be reared. This will usually be satisfactory only after brood rearing has entirely ceased. Unless a colony is quite strong it does not pay to treat in the fall, but it should be destroyed or united to another colony. In case a diseased colony dies outdoors in the winter there is danger that other bees may have opportunity to rob the hive before the beekeepers can close the entrance. In case bees are wintered in the cellar it is more advisable to risk wintering before treatment, for if the colony does die the hive will not be robbed.

Drugs.

Many European writers have in the past advocated the use of various drugs for feeding, in sugar sirup, to diseased colonies, or the fumigation of contaminated combs. In the case of American foul brood, of which the cause is known, it has been found that the drugs recommended are not of the slightest value and no time should be wasted in their use.

TREATMENT FOR EUROPEAN FOUL BROOD.

European foul brood is a very peculiar disease and its cause has not yet been satisfactorily determined. It is, therefore, impossible to discuss the treatment of this disease as definitely as that of American foul brood. From the experience of many careful beekeepers it is, however, possible to suggest some additional manipulations which may be tried by experienced beekeepers. The treatments given previously are strongly recommended for this disease.

Introduction of Italian Stock.

Since, as stated previously (p. 11), Italian bees seem to be better able to withstand European foul brood than are other races, it is recommended that apiaries in regions where this disease is prevalent be requeened with young, vigorous Italian queens of good stock. This should be done whether or not the shaking treatment is given.

Dequeening.

It has been found that the removal of the queen and the keeping of the colony queenless for a period often results in the disappearance of European foul brood. The length of time that this should be done is in dispute. Mr. E. W. Alexander, who advocated this method,[1] recommended that the colony be kept queenless (by cutting out all queen cells at the end of 9 days) for a period of 20 days, at which time a cell containing a queen of Italian stock ready to emerge is to be given the colony. The young queen will thus begin to lay in about 27 days after the old queen has been removed, or in at least 3 days after the last of the drone brood has emerged. Other writers have advocated a shorter time.

The dequeening treatment is not always successful, and it is therefore recommended that care be exercised in trying it. Since there is a considerable percentage of successful results, this would indicate that there is an important principle involved. It should not be forgotten, however, that European foul brood often disappears in the late summer of its own accord if the case is not severe (p. 11), and it is probable that in many of the cases of dequeening reported as successful the disease would have disappeared without the treatment. This treatment is suggested only for the experienced beekeeper.

INSPECTION OF APIARIES.

Several States have passed laws providing for the inspection of apiaries for contagious disease and creating the office of apiary inspector. The men holding these offices are usually practical beekeepers, capable of giving excellent advice regarding disease, and it is desirable, when disease exists in a community, that the owners of apiaries take steps to learn who the inspector is and to notify him of the existence of disease. The Bureau of Entomology of this department can usually give information concerning the inspector and is always glad to be of service in bringing the beekeepers and inspectors in touch with one another.

Apiary inspection has proved beneficial to the beekeeping industry in spreading information concerning the nature, symptoms, and treatment of the contagious diseases and particularly in compelling negligent and careless beekeepers to treat their diseased colonies. It is quite possible for the individual beekeeper to clean up his own apiary by following the directions given in this bulletin, but unless all of the beekeepers in the neighborhood do the same thing there will probably be a recurrence of the trouble due to infection from outside apiaries. It is therefore manifestly to the advantage of the beekeepers that they cooperate with the inspectors in the fight against diseases.

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[1] Alexander, E. W.—How to rid your apiary of black brood. Gleanings in Bee Culture, vol. 33, pp. 1125–1127, 1905.

EXAMINATION OF SAMPLES OF DISEASED BROOD.

The Bureau of Entomology of this department is prepared to assist in the diagnosis of disease in cases where the beekeeper is unable to tell whether or not disease is present, or to determine which disease is in his apiary. Samples of brood comb about 5 inches square containing diseased or dead larvæ should be sent by mail in a strong wooden or tin box. The comb should not be wrapped in paper or cotton, but should be cut to fit the box closely. It is not possible to diagnose from empty combs, and no honey should be included in the sample, as it is valueless in diagnosis and will probably spoil the sample as well as other mail matter. The name of the sender must always appear on the package, and any available data should be sent in a separate letter. Never inclose a letter in the box with the sample.

THE DISEASES OF ADULT BEES.

The diseases affecting adult bees are but imperfectly known. At present four are known to beekeepers by name. Whether these are entirely distinct or whether under each name one or more diseases are included is not known. As stated in the introduction, these diseases have not been sufficiently investigated to give much help to the practical beekeeper.

DYSENTERY.

Dysentery affects bees only in the winter and is manifested by a distension of the abdomen, due to an accumulation of fecal matter in the intestine. When a day warm enough for flight occurs the bees fly from the hive to cleanse themselves, and the hive and surroundings are spotted with yellow excreta. After a good cleansing flight the trouble usually disappears, but if the bees are unable to fly they often die in great numbers. It is generally believed that dysentery is due to improper winter stores, the honey containing too high a percentage of indigestible matter. Honeydew honey almost always produces dysentery, while bees wintered on high-class honey or sugar sirup are not affected. From the wide experience of many beekeepers in this matter it is safe to assume that this explanation of the disease is the correct one, and consequently great care should be exercised that the colonies are provided with good stores for winter.

Recently it has been claimed that there are two types of dysentery, one form as above described and another form which is infectious. American beekeepers are not familiar with an infectious dysentery, and in practical manipulations it is necessary to consider only the type above described.

THE SO-CALLED PARALYSIS.

It is quite possible that under the name "paralysis" are included several distinct diseases. This is indicated by the variety of symptoms reported by beekeepers and the number of different seasons and conditions under which the disease is supposed to occur. The usual manifestation described is that the worker bees are seen crawling in front of the hive with their abdomens trembling. The abdomens are also frequently distended. The bees often climb grass blades and on attempting to fly from the top fall again to the ground. Frequently the bees so affected are almost hairless. The same trembling motion may often be observed on opening the hive. The colony is often depleted very rapidly. There is no evidence that the disease is infectious.

The cause of this peculiar trouble is unknown, and no remedy can be recommended. It is claimed by some writers that a salt-water spray applied to the combs or salt or sulphur sprinkled on the top bars or entrance is sometimes an effective remedy.

ISLE OF WIGHT DISEASE.

Recently a supposedly infectious disease of adult bees has decimated the bees on the Isle of Wight and is said to be spreading in England. It resembles somewhat the so-called paralysis. No treatment other than destruction to prevent the spread of the disease has been recommended. So far as is known no trouble of this kind has been experienced in America.

SPRING DWINDLING.

It sometimes happens that the adult bees in a colony die off in the spring more rapidly than they are replaced by emerging brood. This dwindling may be diminished somewhat by keeping the colony warm and by stimulative feeding, so that all of the energy of the old bees may be used to the best advantage. This condition is probably due to the fact that the colony goes into winter with too large a percentage of old worn-out bees. To prevent this, brood rearing should be continued as late as possible in the fall; if necessary, by stimulative feeding.

PUBLICATIONS OF THE DEPARTMENT OF AGRICULTURE ON BEE DISEASES.

There are several other publications of the Bureau of Entomology of this department which deal with bee diseases. They may be obtained on request to the Editor and Chief of the Division of Publications, Department of Agriculture, and are the following:

Circular No. 94, "The Cause of American Foul Brood." By G. F. White, Ph. D. 1907. 4 pp.

This publication contains a brief account of the investigations which demonstrated for the first time the cause of one of the brood diseases of bees, American foul brood.

Bulletin No. 70, "Report of the Meeting of Inspectors of Apiaries, San Antonio, Tex., November 12, 1906." 1907. 79 pp., 1 pl.

Contains an account of the history of bee-disease investigations, the relationship of bacteria to bee diseases, and a discussion of treatment by various inspectors of apiaries and other practical beekeepers who are familiar with diseases of bees.

Bulletin No. 75, Part II, "Wax Moths and American Foul Brood." By E. F. Phillips, Ph. D. 1907. Pp. 19–22, 3 pls.

An account of the behavior of the two species of wax moths on combs containing American foul brood, showing that moths do not clean up the disease-carrying scales.

Bulletin No. 75, Part III, "Bee Diseases in Massachusetts." By Burton N. Gates. 1908. Pp. 23–32, map.

An account of the distribution of the brood diseases of bees in the State, with brief directions for controlling them.

Bulletin No. 75, Part IV, "The Relation of the Etiology (Cause) of Bee Diseases to the Treatment." By G. F. White, Ph. D. 1908. Pp. 33–42.

The necessity for a knowledge of the causes of bee diseases before rational treatment is possible is pointed out. The present state of knowledge of the causes of disease is summarized.

Technical Series, No. 14, "The Bacteria of the Apiary, with Special Reference to Bee Diseases." By G. F. White, Ph. D. 1906. 50 pp.

A study of the bacteria present in both the healthy and the diseased colony, with special reference to the diseases of bees.

FARMERS' BULLETINS.

Bulletins in this list will be sent free, so long as the supply lasts to any resident of the United States, on application to his **Senator, Representative, or Delegate in Congress,** or to the Secretary of Agriculture, Washington, D. C. *Because of the limited supply, applicants are urged to select only a few numbers, choosing those which are of special interest to them.* Residents of foreign countries should apply to the Superintendent of Documents, Government Printing Office, Washington, D. C., who has these bulletins for sale. Price 5 cents each to Canada, Cuba, and Mexico, 6 cents to other foreign countries. The bulletins entitled "Experiment Station Work" give briefly the results of experiments performed by the State experiment stations.

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Issued June 12, 1911.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 443.

BARLEY:
GROWING THE CROP.

BY

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WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., February 4, 1911.

Sir: I have the honor to transmit and to recommend for publication as a Farmers' Bulletin the accompanying manuscript, entitled "Barley: Growing the Crop," prepared by Mr. H. B. Derr, Agronomist in Charge of Barley Investigations, under the direction of Mr. M. A. Carleton, Cerealist in Charge of Grain Investigations.

Of the small-grain crops grown in this country barley ranks third in production. While much of the area devoted to this crop in the United States is suited to its production, the lack of care in selecting seed and the methods of cultivation practiced result in low yields of poor quality. This bulletin gives directions for the best methods of growing and harvesting the crop. With the use of these methods there should be a marked increase in the yield and quality of the barley grown in the United States.

In the preparation of this bulletin data have been used from the reports of superintendents of experimental farms of the Department of Agriculture, from the reports of cooperators, and from the publications of various agricultural experiment stations.

Respectfully,

Wm. A. Taylor,
Acting Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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BARLEY: GROWING THE CROP.[a]

INTRODUCTION.

While much of the early history of barley is uncertain it is generally admitted that it was one of the first cereals to be cultivated. Its cultivation in the United States dates back to the time of the earliest colonists, but the introduction of improved varieties[b] did not begin until the middle of the nineteenth century. The production of barley has rapidly increased in late years, until at present it ranks fourth in value among cereals.

Fully half the crop is used for brewing and malting; but careful feeding trials conducted by the various agricultural experiment stations and by many farmers have demonstrated its worth for feeding, especially to cattle, hogs, and sheep. This knowledge of its feeding value has tended to considerably increase the production, especially in areas where the production of corn is rather uncertain.

The annual yield per acre in the United States for the past ten years, as given by the Bureau of Statistics, is only 25.7 bushels, while that of Germany and Great Britain is more than 8 bushels greater. When we consider that in the States of California, Texas, Kansas, Nebraska, and North Dakota, the average yield of barley for the past ten years has been less than 25 bushels per acre, and in 24 of the States the yield has been considerably less than 30 bushels, there is no doubt that with proper efforts along the lines of seed selection and preparation of the soil, the average yield can be considerably increased and made to compare more favorably with that of Germany and Great Britain.

ORIGIN AND EARLY HISTORY OF BARLEY.

Barley is supposed to be a native of western Asia, where wild forms still exist. Some botanists claim that the original type from which all of our cultivated varieties have been produced is *Hordeum spontaneum*, a wild, two-rowed form found on the barren hillsides of Palestine. Others believe that there was a wild six-rowed form, as all of the ancient inscriptions are of the six-rowed and not of the two-rowed type.

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[a] Other publications relating to barley, which may be obtained free upon request to the Secretary of Agriculture, Washington, D. C., are "Barley Culture in the Southern States," Farmers' Bulletin 427, U. S. Dept. of Agriculture, 1910; "Barley Culture in the Northern Great Plains," Circular No. 5, Bureau of Plant Industry, 1908; "The Separation of Seed Barley by the Specific Gravity Method," Circular 62, Bureau of Plant Industry, 1910.

[b] The word "variety" is used in this bulletin in the ordinary commercial sense and does not usually refer to a pure race or pedigreed strain.

Barley was cultivated by the people of western Asia nearly 2,000 years before the Christian era. Pliny makes the statement that barley was among the first cereals cultivated for food. This grain is mentioned by early writers in Egypt, and the high esteem in which it was held is shown by the fact that Egyptian coins estimated to be several thousand years old bear figures of barley heads. Specimens of this grain taken from Egyptian tombs, estimated to be over 3,000 years old, are in the British Museum; representations of barley heads are also found on these tombs.

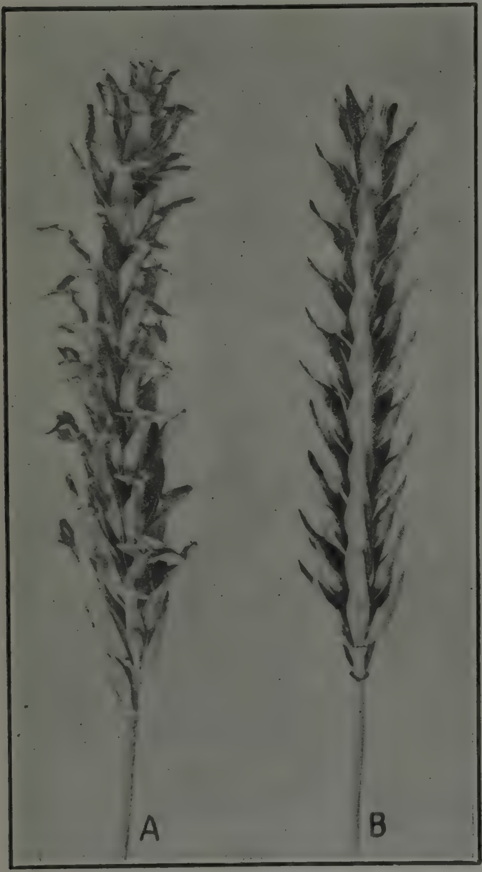

FIG. 1.—The two types of awnless barley: *A*, Hooded; *B*, the new hybrid awnless variety, Arlington Awnless.

As a crop, barley is mentioned in Exodus (ix, 31) and in other books of the Bible, and from all indications the greater portion of the grain in Biblical times was barley. It was evidently among the chief food-producing plants of the Jewish race and of the surrounding nations. From western Asia barley was early introduced into southern Europe and gradually spread northward. Its cultivation in early times is shown by the finding of charred grains in the homes of the prehistoric people of Europe. Ancient historians, including Pliny and Theophrastus, refer to the value of this grain for both food and drink. The armies of Europe in early times largely subsisted on barley. After the introduction of wheat and rye these grains gradually replaced barley for human food, especially in Europe, but it is still so used in portions of western Asia.

BOTANICAL CHARACTERS.

General description.—Barley belongs to the Gramineæ or grass family and to the genus Hordeum. The different groups of cultivated barley have usually been considered as distinct species, but they are now regarded by some botanists as varieties of a single species, *Hordeum sativum.*

The plant is somewhat similar to wheat and rye, although generally not so tall. It tillers quite freely, some varieties producing as high as 15 culms, depending on the thickness of planting and the fertility of the soil. The leaves, which are of a grayish-green color, are broader than those of other grains.

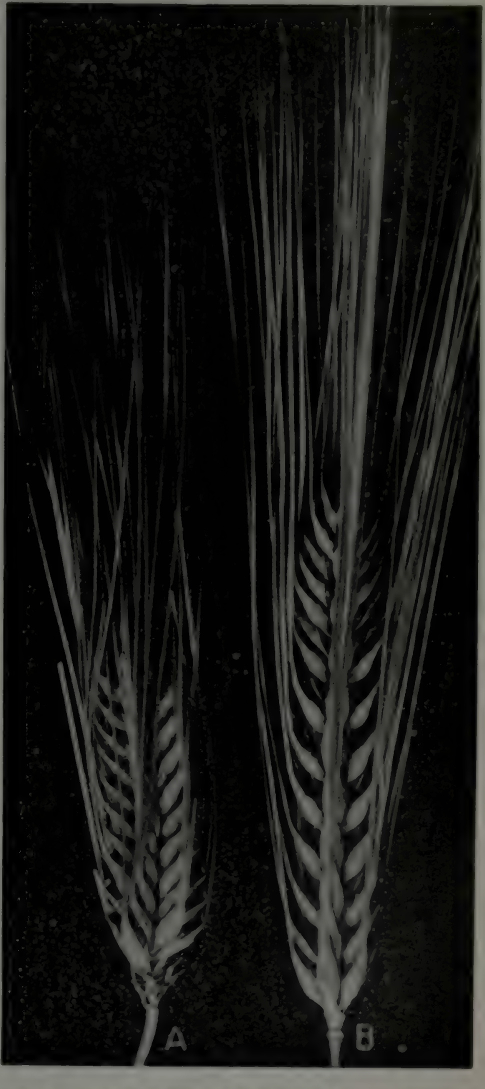

FIG. 2.—The two types of six rowed barley grown in the United States: *A*, Round six rowed (*Hordeum hexastichon*); *B*, Square six-rowed (*Hordeum vulgare*).

The head of barley, as of wheat or rye, is a spike in which the spikelets or flower clusters are arranged along a central stem or rachis. This rachis is made up of short joints, curved alternately in opposite directions, giving it a zigzag appearance. The spikelets are arranged in groups of three at the upper end of each joint, each group lying in the inner side of the curve of the joint above. In the six-rowed barley all the spikelets are fertile. In the two-rowed barley, however, only the central spikelet produces grain, the two lateral spikelets being infertile, thus giving the head the two-rowed appearance.

Each fertile spikelet contains a kernel, which is inclosed in the flowering glume and palea, which together form the hull. In the hull-less varieties these are easily removed in thrashing, as in wheat, while in the common varieties they remain firmly attached to the kernel. In the bearded varieties the median nerve of the flowering glume, which forms the greater portion of the hull, is prolonged into a beard or awn 3 to 6 inches in length. A new form of awnless barley (fig. 1, *B*) has recently been produced by the Office of Grain Investigations. In the hooded, or so-called beardless barleys (fig. 1, *A*), the beard is replaced by a three-pronged appendage, the central portion of which is bent over, giving it a hoodlike appearance.

Surrounding the base of the spikelet, but not attached to it, are small, slender appendages known as the outer glumes. In some varieties the central portion of these extends into a soft, bristle-like awn, while in others it is blunt or slightly pointed. Both the common and the hull-less varieties of the six-rowed bearded and of the six-rowed hooded types are grown. Of the two-rowed bearded type there are both common and hull-less forms; of the two-rowed hooded only the common form is grown in this country.

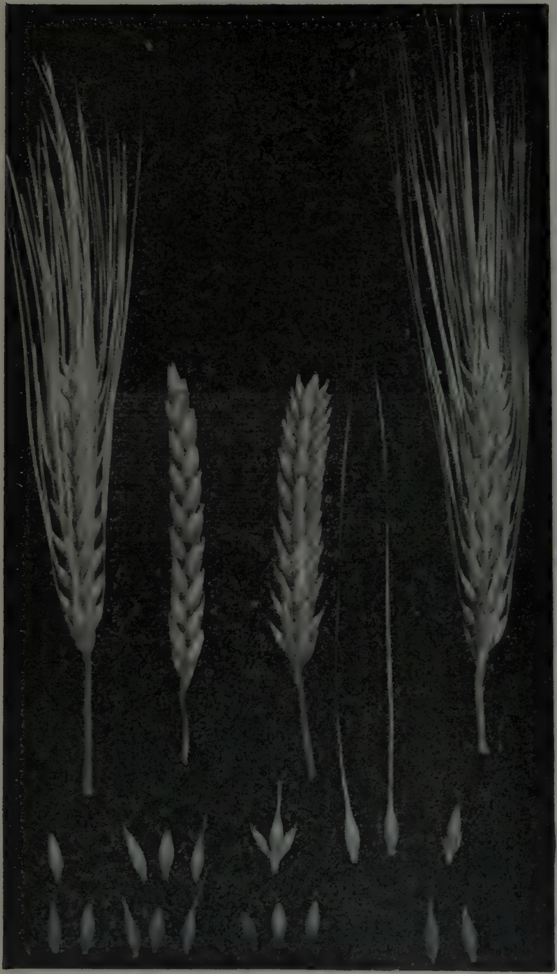

FIG. 3.—The Manchurian or square type of six-rowed barley. The heads with the beards removed show the arrangement of the spikelets. Ninety-five per cent of the six-rowed barleys grown in the United States are of this type. Among the most prominent varieties are Manchuria, Oderbrucker, Odessa, and Common California.

Description of the various types.—The arrangement of the spikelets in the head is the distinguishing character between the round six-rowed barley, *Hordeum hexastichon* (fig. 2, *A*), and the square six-rowed (commonly called four-rowed) barley *Hordeum vulgare* (fig. 2, *B*). In the round barley, of which Utah Winter is the best example, the spikelets appear as if radiately arranged upon the rachis, giving the head a round form, while in the square barley (fig. 3), or Manchurian type, the heads assume a square appearance due to a twisting to either side of the lateral spikelets. Owing to this twisting there is an overlapping of the lateral grains with the resulting square, compact form of head. The bearded hull-less and the hooded varieties are included in the *Hordeum vulgare* group.

Two types of two-rowed barley are cultivated in the United States. One has a long, slender head which bends over or nods when ripe (fig. 4, *B*; fig. 5). The Chevalier barley is a good example of this type. Fully 90 per cent of the two-rowed barleys grown in the United States are of this slender form, which is typical of the *Hordeum distichon* group. The other type has short, broad, erect heads, the awns sometimes spreading (fig. 4, *A*). The Primus variety is a good example of the latter type.

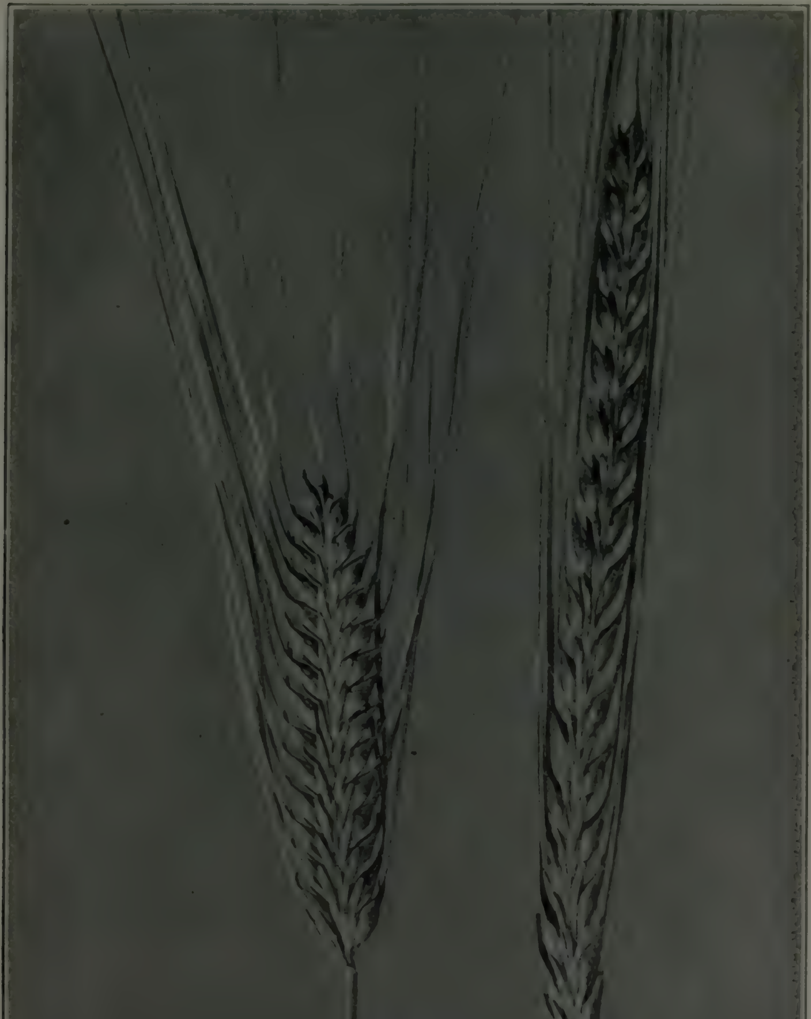

FIG. 4.—The two types of two-rowed barley grown in the United States: *A*, The short form with spreading awns; *B*, the long, slender form which is most typical of *Hordeum distichon*.

Identification of the different groups by means of the grain.—While it is almost impossible to identify the varieties of barley by an examination of the grain alone, the various groups can be readily recognized.

In the bearded barleys the six-rowed type can be identified by the presence of two smaller twisted grains for each large straight one, while in the two-rowed type there are no twisted grains. A mixture of the two-rowed and six-rowed types can be detected by noting the proportion of straight and twisted grains. Figure 6 shows grains of the two groups.

In the hull-less barleys the form and color of the kernels aid in distinguishing them. In the hooded barley, called White Hull-less (fig. 7, *A*), the grains when grown under ideal conditions are large, plump, and of a clear amber color. In the Himalaya (Guy Mayle) barley (fig. 7, *B*), the grain is medium to large and its color is bluish green. Black Hull-less (fig. 7, *C*), which is a bearded variety, can be recognized by the deep-purple color of the grain. The two-rowed bearded hull-less barley (fig. 7, *D*) can be distinguished from the six-rowed by the larger, broader, rather flat grain, usually of a dark amber color with a brown tip.

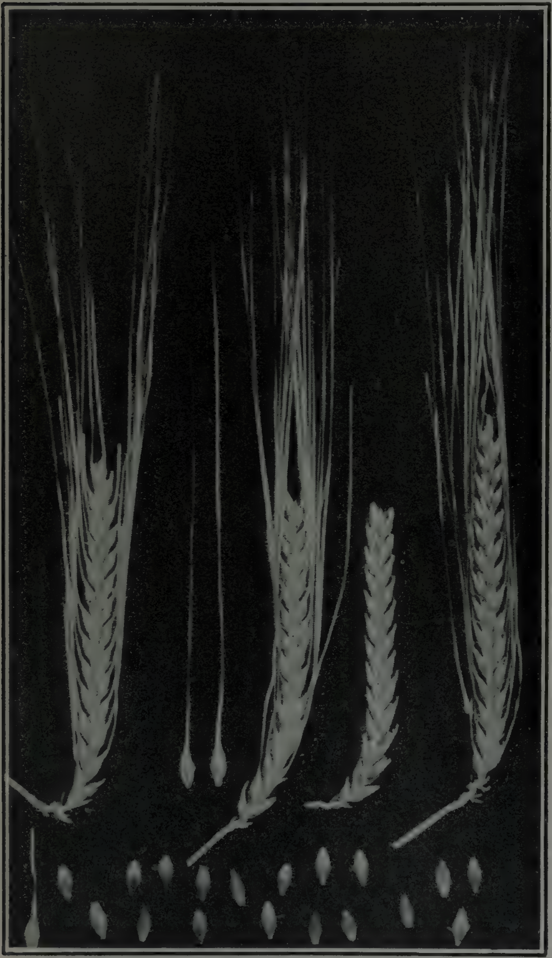

FIG. 5.—Heads and grains of the long, slender type of two-rowed barley. (One head with beards removed.) Fully 90 per cent of the two-rowed barleys grown in the United States are of this type. Among the most prominent varieties are Chevalier, Hannchen, and Hanna.

INTRODUCTION OF BARLEY INTO THE UNITED STATES.

Early introductions.—Barley was introduced and cultivated by the colonists of Massachusetts and Virginia early in the seventeenth century. In the latter part of the same century considerable barley was grown in Rhode Island and by the Dutch in New York. With the movement of colonization westward along the Great Lakes and down the Ohio River, the crop was carried into new areas and soon became extensively cultivated. Its spread has continued to the present time and it is now generally grown in the upper Mississippi Valley and the Rocky Mountain States.

Previous to the organization of the office of Commissioner of Agriculture, a number of new varieties of barley were introduced and distributed by the Commissioner of Patents, the first of these distributions being recorded about 1845. The popularity of the crop was largely increased by the success of these introductions, which included hooded (beardless) and hull-less varieties which have given excellent results in the higher portions of the West.

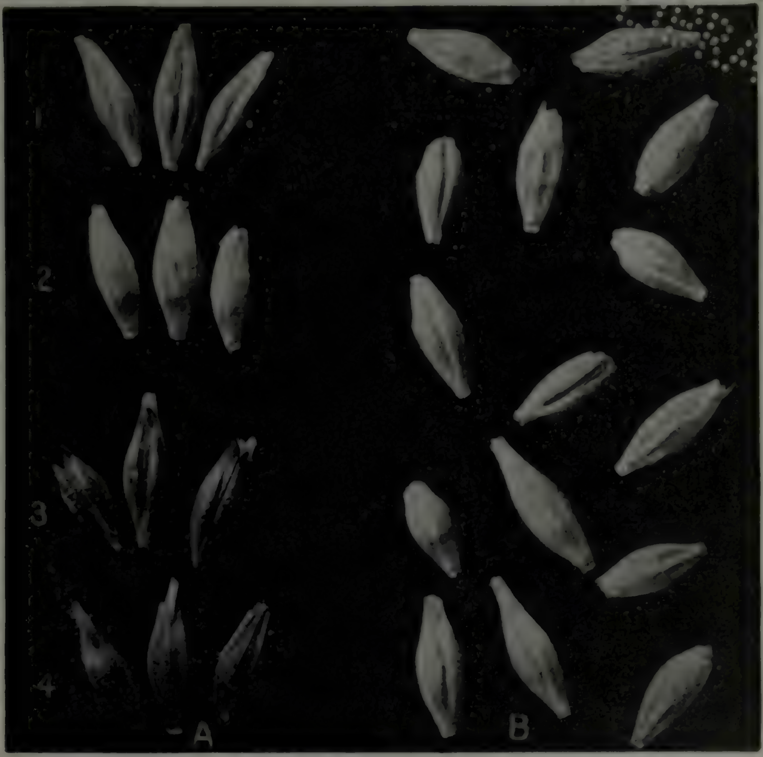

FIG. 6.—Grains of six-rowed and two-rowed barleys, showing differences by which they can be identified: *A*, Six-rowed—Nos. 1 and 3, ventral surface; 2 and 4, dorsal surface of kernels. Note the twisted appearance of the outsite (lateral) kernels as compared with the straight median one. A sample of six-rowed barley should have twice as many twisted (lateral) kernels as straight ones. *B*, Two-rowed—both dorsal and ventral surfaces shown. There should be no twisted grains in a sample of two-rowed barley.

Recent introductions.—The Department of Agriculture, through the offices of Seed and Plant Introduction and of Grain Investigations, has in recent years introduced and distributed a large number of varieties of barley. Several pedigreed two-rowed varieties, including Chevalier, Primus, Princess, Hannchen, and Swan Neck from Sweden, have given excellent results. The excellent yields from these pedigreed barleys in the past few years demonstrate their superiority over the common ones. Among the most promising of the six-rowed barleys introduced by the Department are the Odessa and the Gatami, which are giving good results in the Northwest, leading in yield at several experimental farms. The hooded and hull-less barleys which were introduced from the Himalaya Mountains in Asia, where they are grown at elevations as great as 11,000 feet, and from other sections have matured grain in the United States at 8,000 feet in Idaho and at 9,800 feet in Colorado.

BARLEY-PRODUCING AREAS OF THE UNITED STATES.

Location of the areas.—Barley can be grown in nearly every State, but the greater part of the crop is produced in certain definite areas. The largest area (fig. 8) includes eastern North Dakota and South Dakota, western and southern Minnesota, southern Wisconsin, and northern Iowa. The area next in extent is in California. This crop is also grown in eastern Oregon, eastern Washington, and western Idaho. A small isolated area is found in western New York, and another in southeastern Michigan, northwestern Ohio, and northeastern Indiana. Barley is also produced in eastern Nebraska, western Kansas, northeastern Colorado, southeastern Wyoming, and central Montana. The crop is grown in other States, but the areas mentioned include practically all of those sections in which its cultivation is important.

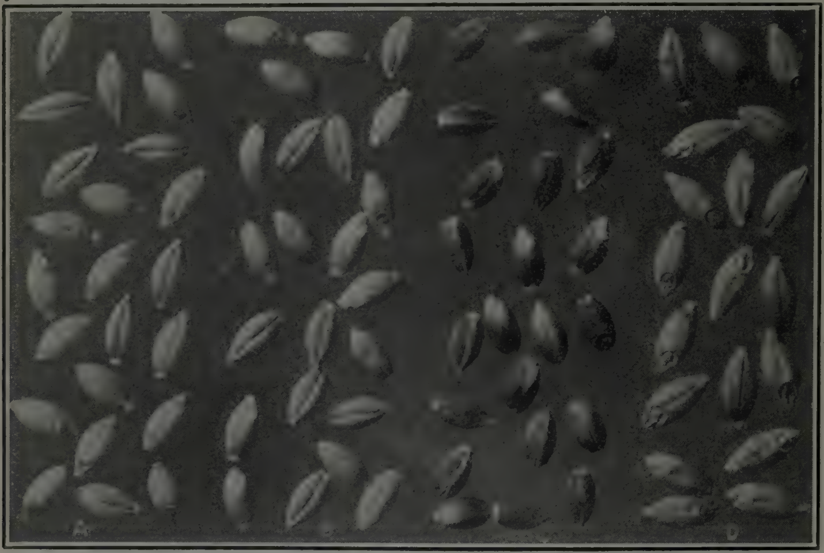

FIG. 7.—Grains of four varieties of hull-less barley: *A*, White Hull-less, six-rowed; color of grain, pale amber. *B*, Himalaya (Guy Mayle), six-rowed; color, bluish green. *C*, Black Hull-less, six-rowed; color, purple. *D*, Two-rowed Hull-less; color, dark amber.

Types of barley adapted to these areas.—Different types of barley are adapted to the various areas, or even to definite portions of a single area. Thus, in the largest barley-growing district, the six-rowed barleys, Manchuria, Oderbrucker, and Odessa, as shown in a previous publication,[a] do best in Minnesota, Wisconsin, Illinois, Iowa, and

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[a] Carleton, M. A. Barley Culture in the Northern Great Plains. Circular 5, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1908.

Nebraska, while in North Dakota and South Dakota the two-rowed varieties, such as Hannchen, Swan Neck, Chevalier, and Hanna, give better results. Six-rowed barley is principally grown in western New York and in Michigan, Ohio, and Indiana. In Kansas, Oklahoma, Texas, and the Southern States generally the most profitable variety to grow is the six-rowed Tennessee Winter. In the high altitudes of the Rocky Mountain States hooded barley is the most profitable type. In Utah and Idaho the six-rowed type, both spring and winter, gives the best results, Utah Winter being the most profitable variety. In the Pacific States the six-rowed varieties, Bay Brewing and California Feed, are the most common, although some excellent barley of the two-rowed varieties, Chevalier and Hanna, is also produced.

The hooded and hull-less barleys (fig. 9) have proved successful in the semiarid regions of the West, where they are superior to any other type, especially in the high altitudes where little other grain matures. They also grow well under irrigation. Up to the present time they have not proved adapted to the humid sections of the East, as the excessive heat prevents the filling of the grain, and the moisture induces a weak straw that lodges readily.

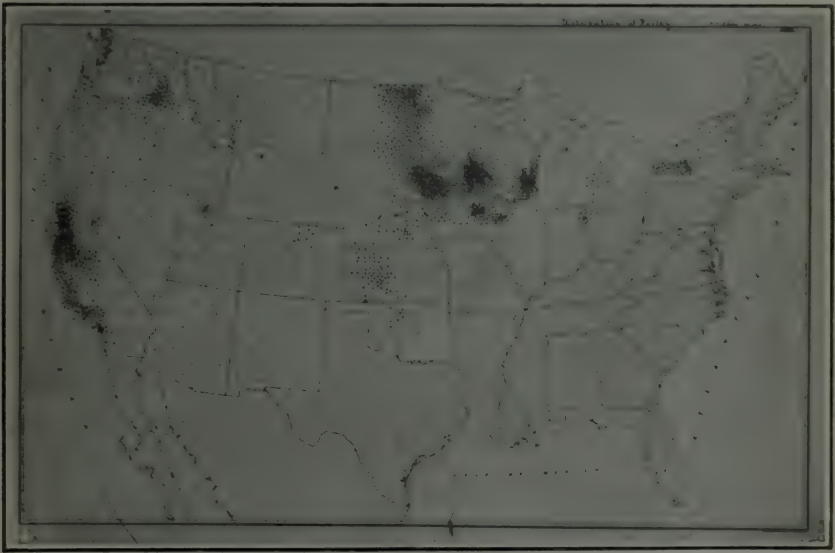

FIG. 8.—Map showing the barley producing areas in the United States, according to the census of 1900. Each dot indicates 2,000 acres of barley.

SOILS ADAPTED TO THE CROP.

Barley requires a richer and more porous soil than wheat. It does best on well-drained loam soils, though the volcanic soils of the Northwest also give good results. This crop can be produced on sandy loam, but on this type of soil it is more susceptible to unfavorable climatic conditions than on silt or clay loam. In any case the soil should contain considerable humus and be in good physical condition.

Heavy, undrained clays are not adapted to the growing of barley. The roots of this plant are comparatively weak and do not penetrate such soils as readily as those of wheat. Soils of this type are especially undesirable for winter barley, for while a stand may usually be obtained, the crop is likely to be injured by the alternate freezing and thawing of winter and early spring. Owing to the fineness of the soil particles, heavy clays are much more subject to washing than are the more porous loams. This washing exposes the roots of the young plants and is another cause of the failure of winter barley on this type of soil.

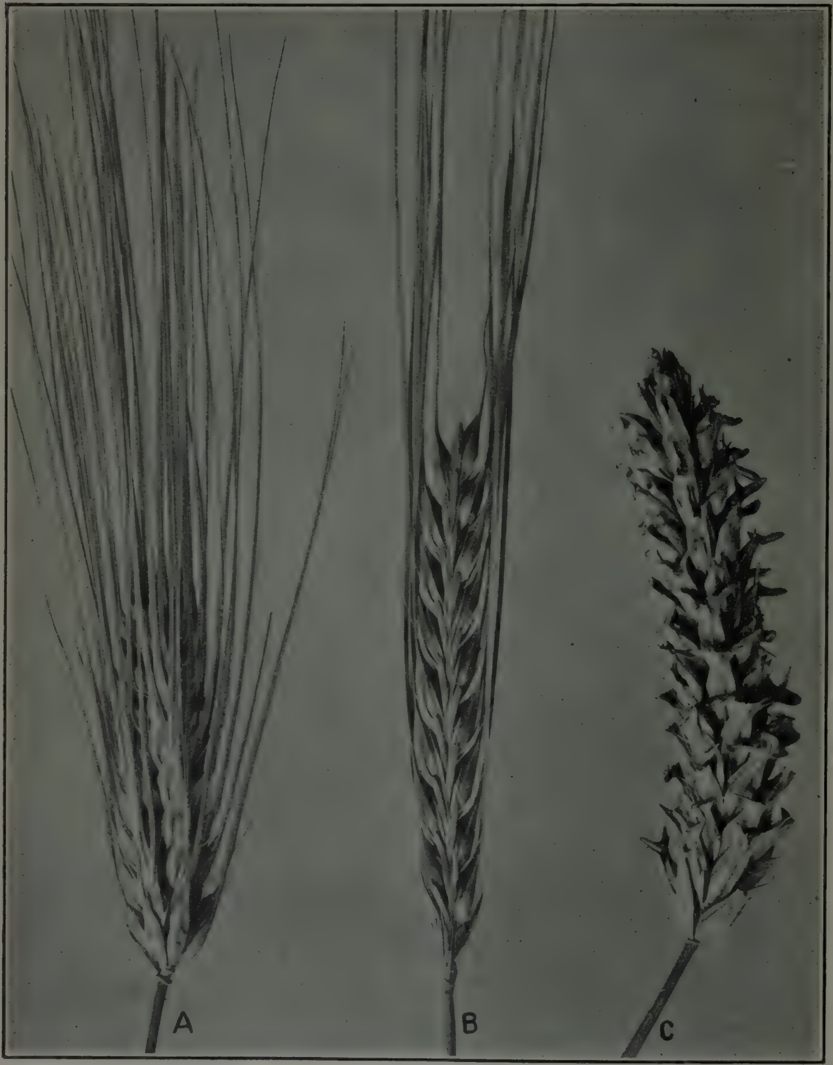

FIG. 9.—The three types of hull-less barley now in cultivation: *A*, Six-rowed bearded hull-less (Black Hull-less); *B*, two-rowed bearded hull-less (Two-rowed Hull-less); *C*, six-rowed hooded hull-less (White Hull-less).

Well-drained, well-fertilized, gravelly clay soils have in some instances given good results in barley production. Loose, sandy soils, while easily prepared, are often deficient in plant food, while their inability to retain moisture makes them of doubtful value for the production of this crop. Though the moisture-retaining capacity may be largely increased by the addition of stable or green manures, the results will not be as satisfactory as those obtained on fertile loams. The greater ability of the loam to retain moisture insures better and more uniform germination during periods of drought, an important factor in the success of the crop.

In regard to the cultivation of barley on light, sandy soil, Mr. H. F. Blanchard, in charge of the cooperative grain experimental station at Modesto and Ceres, Cal., in a report says:

> On light, sandy soil the crop matures early, but the growth and stooling are poor and the heads small. On the heavier soils a greatly improved condition of growth and yield was shown.

Experiments conducted for several years at the Tennessee station showed the relative value of fertile and poor soils for barley culture. On fertile soil the yield averaged 65 bushels to the acre, while on poorer soil the yield was only 28.5 bushels.

Well-drained soil is essential for the best success with barley, as shown by experiments in Wisconsin. At Center drained land produced 36.72 bushels to the acre, while undrained land produced but 25.75 bushels. At Appleton the difference in favor of the drained land was 11 bushels to the acre.

FERTILIZERS AND MANURES.

General statement.—Barley is rather shallow rooted as compared with other cereals. As careful field observations show that the greater portion of the feeding roots are confined to the upper 6 inches of soil, the plant food should be near the surface and in an available form. This is one of the reasons why barley responds so readily to commercial fertilizers.

Barnyard manure.—Barnyard manure is the best fertilizer for barley, if it is available in sufficient quantity and is applied at the right time. It is superior to commercial fertilizers because in addition to the three essential elements—nitrogen, phosphorus, and potassium—it contains vegetable matter which improves the physical condition of the soil. On the loamy soils of the West the addition of vegetable matter is not so important, but on the clay soils of the South it has much to do with the success of the crop. Compact soils are made open and porous by the addition of barnyard manure, while the vegetable matter absorbs and holds moisture and prevents the drying and baking so common on such soils. It has been demonstrated, however, that plowing under coarse barnyard manure just before sowing barley seldom gives good results. Its effect on the physical condition of the soil is generally injurious, making it too open and porous. If plowed under some time before seeding, the plant food becomes available, the soil has time to settle, and the results are beneficial.

Green manures.—Where the soil is deficient in plant food and humus, the plowing under of clover, alfalfa, cowpeas, or other green-manure crops some time previous to the sowing of barley is of benefit. In figure 10 the operation of plowing under cowpeas on a heavy clay soil is shown. Figure 11 shows the excellent growth of barley produced on a clay-loam soil after the plowing under of a green-manure crop. On lands already rich in nitrogen, plowing under these crops generally causes lodging, consequently they must be used with judgment. It is sometimes necessary to apply lime to correct the acidity due to the decay of green vegetation.

The reduced yields of grain in recent years have shown that the soils of the barley-producing areas are not inexhaustible. The barnyard manure produced is not sufficient to replace the fertility removed by the crops, and the use of green manures is advocated wherever possible.

At the Montana station, barley after peas gave a yield of 67.7 bushels, but after a grain crop it yielded only 35 bushels. At the Utah station a crop of field peas plowed under increased the yield of barley from 7.22 bushels to 22.56 bushels.

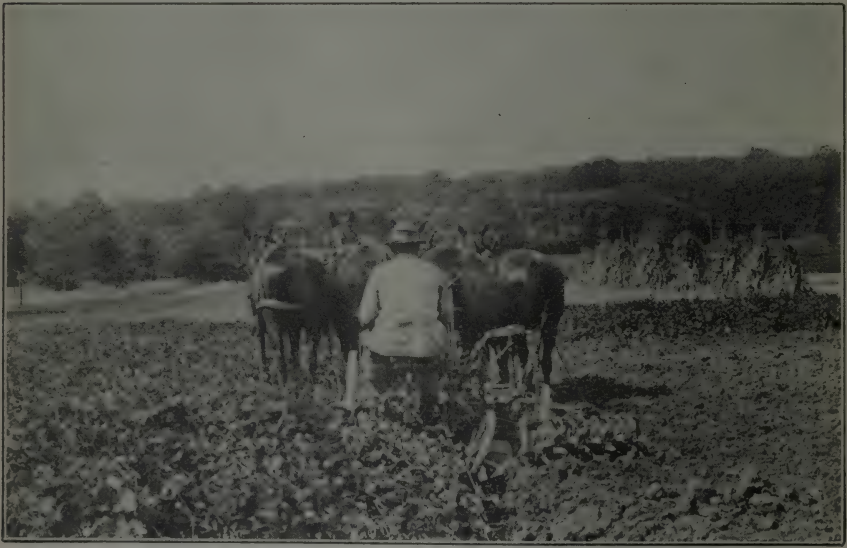

Fig. 10.—Plowing under cowpeas as a green-manure crop.

Commercial fertilizers.—Where barnyard or green manures are not available, it is sometimes necessary to use commercial fertilizers in order to produce good crops of barley. The quantity and kind of fertilizer to be used depends on the requirement of the crop and the fertility of the soil. If the plants lack vigor and are of poor color, though climatic and other conditions are favorable, it is an excellent indication of a lack of nitrogen and phosphorus. In favorable seasons, if the grain fails to fill properly, the necessity of increasing the quantity of phosphates and potash is indicated. Frequently a complete fertilizer containing the three important elements, nitrogen, phosphorus, and potassium, may be necessary. Barley usually has large, heavy heads and consequently requires a stiff straw to prevent the plant from lodging. The fertilizer should, therefore, contain a higher percentage of potash and phosphorus than of nitrogen.

Where barley follows cowpeas or other leguminous crops nitrogen can frequently be omitted from the fertilizer used, this element being furnished by these crops, but the phosphorus and potash will have to be supplied. In this case the application of 200 pounds of acid phosphate and 75 pounds of muriate of potash per acre will give good results. Raw rock phosphate may be used instead of the acid phosphate. It becomes available more slowly, but the beneficial effect extends over a much longer period. Raw rock phosphate does not increase the acidity of the soil as does the acid phosphate. Best results will be obtained from the use of the rock phosphate if it is added to stable manure before the latter is applied or if it is plowed under with a green-manure crop. Hon. W. D. Hoard, of Jefferson County, Wis., reports that on his farm a field of alfalfa which had been heavily manured two years previously was plowed up and sown to barley. A yield of 35 bushels to the acre was obtained. A similar field on which manure treated with raw rock phosphate was applied gave a yield of 51 bushels. The increase of 16 bushels was accredited to the use of rock phosphate.

FIG. 11.—A field of six rowed barley grown after a green manure crop.

On the clay soils of the Arlington Experimental Farm, near Washington, D. C., where large crops of cowpeas and rye are plowed under, excellent yields of barley are produced when 200 pounds of acid phosphate per acre are applied. At the Maryland station a complete fertilizer is used, which is mixed when needed. It consists of 300 pounds tankage, 200 pounds muriate of potash, 100 pounds nitrate of soda, and 1,400 pounds of 14 per cent acid phosphate. This is applied at the time of seeding at the rate of 300 to 400 pounds per acre.

A fertilizer that has given excellent results with grain crops in the Southern States is made up of 1,400 pounds of acid phosphate, 200 pounds tankage, 200 pounds muriate of potash, 100 pounds nitrate of soda, and 100 pounds dried blood. This is applied at the rate of 200 to 300 pounds per acre. In this fertilizer some of the nitrogen is immediately available, while the remainder becomes available slowly, thus furnishing material for growth throughout the season. Another mixture which has given satisfaction consists of 200 pounds acid phosphate, 50 pounds muriate of potash, and 50 pounds nitrate of soda, applied at the rate of 300 pounds to the acre. A light application of nitrate of soda after the plants are up will prove beneficial on poor soil.

At the Kansas station the application of about 200 pounds of sodium nitrate per acre gave an extremely vigorous growth and in one experiment nearly doubled the yield. At the Wyoming station an application of sodium nitrate to hull-less barley when the plants were several inches high increased the yield of hay from 2,457 to 4,918 pounds per acre.

When the seed is sown with a drill, commercial fertilizer is usually drilled in with the seed. Where the seed is sown broadcast, the fertilizer is generally applied by means of a special fertilizer attachment and is harrowed in before seeding. Instead of using a ready-mixed fertilizer it is sometimes advisable to purchase the ingredients and mix the fertilizer as it is needed.

The use of lime.—Acid soils are not adapted to barley culture. The Maryland station conducted experiments for a number of years with liming the soil for both barley and wheat and considers the application of 30 to 40 bushels of lime per acre most profitable. The Tennessee station obtained excellent results by applying 25 bushels of lime per acre the year previous to planting barley. Finely ground limestone may be used in place of burnt lime, but double the quantity is necessary to obtain the same results. Experiments conducted by the Rhode Island station on the liming of soils throughout the State indicate that considerable benefit is derived from the use of lime, even if applied directly before seeding barley.

Many farmers in the South obtain good results with clover after barley from drilling in 500 to 1,000 pounds per acre of ground lime just before sowing the barley. Drilling in the lime has also given excellent results on the Arlington Experimental Farm. When the lime is drilled in it is distributed much more evenly than when sown broadcast. Lime can also be distributed with a manure spreader.

BARLEY IN THE ROTATION.

EFFECT OF THE PRECEDING CROP.

In the greater portion of the United States barley has no fixed place in the rotation, but is generally sown without regard to the preceding crop. The market demand and the necessity for feed are the factors which usually influence the acreage.

The preceding crop has considerable influence on the yield of barley. At the Tennessee station it was found that winter barley after cowpeas were turned under yielded 56 bushels, while after corn the yield was only 41 bushels. This indicates that on clay soils in the Southern and Central States, where the supply of humus is usually deficient, a different rotation is necessary from that practiced on the rich prairie or alluvial soils where barley, after corn, potatoes, or wheat, usually gives good results.

At the South Dakota station various rotations have been practiced for a number of years. These have given an excellent opportunity to study the effect of the preceding crop on barley. Table I shows the average yields per acre of barley in pounds of straw and bushels of grain in several rotations for three years.

Table I.—*Average yields of barley, both grain and straw, in 5 different rotations in a 3-year test at the South Dakota station.*[a]

Rotation.	Yield per acre.		Straw per 1 pound of grain.
	Straw.	Grain.	
Barley after wheat:	*Pounds.*	*Bushels.*	*Pounds.*
Wheat, barley, peas (plowed under), wheat, corn	1,983	35.75	1.16
Wheat, barley, peas (cut), wheat, corn	2,210	40.66	1.13
Barley, millet, wheat	1,920	34.66	1.36
Barley, peas (cut), wheat	1,630	35.00	.96
Average	1,936	36.52	1.15
Barley after flax:			
Flax, barley, millet, wheat, corn	2,075	40.20	1.07

[a] Bul. 79, South Dakota Agricultural Experiment Station.

In the rotation where flax preceded barley, the yield of barley was nearly 3 bushels greater than the average of the 4 rotations in which barley followed wheat, indicating that flax is a better crop than wheat to precede barley. Professor Chilcott states that the rotation in which barley followed flax was satisfactory for South Dakota.

Better yields are generally obtained where barley follows a cultivated crop than when it follows a small-grain crop. Valuable data have been collected by the Ontario Agricultural College on the effect of the preceding crop on barley. The average yield of barley grown after root crops was 27.75 bushels to the acre as reported by 337 correspondents, while 535 reported growing barley after other crops, with average yields of 24.5 bushels. The weight per bushel of cleaned seed was practically the same, 51.5 pounds. The average yield of barley for Ontario as reported by 1,015 correspondents was 22.2 bushels per acre. The barley grown after roots gave a yield of 5.5 bushels higher than the average. At the Ontario Agricultural College the best yields of barley were produced after potatoes, turnips, or carrots, especially when the land was plowed and well prepared for these crops.

In another experiment in Canada, barley, oats, and wheat were sown after summer fallow, wheat, and emmer. The largest yields were obtained where these crops were sown after emmer, and the poorest yields where they followed wheat.

COMMON ROTATIONS WHICH INCLUDE BARLEY.

A rotation which has given satisfaction in Minnesota consists of one year of corn; one year of barley, grass seed being sown with the grain; meadow and pasture as long as desired. Flax may take the place of corn, or may immediately precede it. A rotation planned to keep up the soil fertility consists of corn two years; barley one year, with grass or clover sown with it; hay two years, or meadow one year, and pasture one or more years. The grass land should be manured before breaking for corn.

In the Dakotas barley frequently follows wheat, the wheat stubble being disked and the barley drilled in. Where corn and oats are grown it may follow either of these crops. It generally does best, however, when following corn or where a leguminous or green-manure crop has been plowed under the preceding year. On many farms wheat is grown almost continuously, barley being grown only where a change of feed is desired, or when the land becomes weedy.

In Kansas, where alfalfa is grown, corn frequently follows that crop, while barley or other small grains follow corn. In Montana, where the growing of small grain predominates, a rotation which includes two years of clover followed by three crops of small grain, in the last of which clover is again sown, has given good results.

A 4-year rotation recommended for Wyoming is peas, grain, potatoes, grain. A good 6-year or 7-year rotation is as follows: Alfalfa, three years; fourth year, grain; fifth year, potatoes; sixth year, or sixth and seventh years, grain. In Utah, Nevada, and Idaho no definite rotation is commonly followed, and barley is sown after fallow or any crop. To obtain best results, however, a rotation should be practiced which includes leguminous crops. In the Pacific States barley generally follows summer fallow or wheat. In some localities barley is sown continuously on the same land for a number of years.

In a comparison between continuous cropping and the average of two 3-year rotations at 11 stations in the Great Plains area, Chilcott [a] found that under the former method barley averaged 21.1 bushels to the acre, while in the rotations the yield was 24.3 bushels, an increase of 3.2 bushels where rotation was practiced. This increase in yield was obtained without a corresponding increase in cost of production. The rotations which included barley were: (1) Barley on disked corn ground, oats on ground plowed early the preceding fall, corn on ground plowed early the preceding fall; (2) oats on spring-plowed land, barley on spring-plowed land, corn on spring-plowed land.

Rotation No. 1 gave an average yield of 25.9 bushels per acre at the 11 stations, and rotation No. 2 averaged 22.83 bushels. Table II gives the yields of barley obtained in these rotations at each of the stations, showing also the yield from continuous cropping for comparison.

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[a] Chilcott, E. C. A Study of Cultivation Methods and Crop Rotations in the Great Plains Area. Bulletin 187, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1910.

TABLE II.—*Yield of barley in two 3-year rotations compared with continuous cropping.*

Station.	Year.	Average yield per acre (bushels).		
		Rotation No. 1.	Rotation No. 2.	Continuous cropping.
Judith Basin, Mont	1909	42.7	39.1	45.2
Dickinson, N. Dak	1908	45.6	34.4	33.5
Do	1909	53.8	49.2	39.8
Edgeley, N. Dak	1907	18.3	10.6	10.2
Do	1908	31.9	26.0	25.6
Do	1909	33.1	32.7	27.0
Highmore, S. Dak	1906	37.7	29.2	....
Do	1907	25.0	28.3	30.2
Do	1908	30.6	29.9	29.8
Bellefourche, S. Dak	1909	47.1	28.1	23.8
North Platte, Nebr	1907	30.6	40.2	39.0
Do	1908	24.9	22.3	19.6
Do	1909	21.5	18.5	....
Akron, Colo	1909	24.9	22.2	19.7
Hays, Kans	1908	12.3	9.2	5.8
Garden City, Kans	1909	5.1	5.7	2.4
Dalhart, Tex	1909	0	0	0
Amarillo, Tex	1908	7.5	8.1	7.9
Do	1909	0	0	0
Average		25.9	22.83	21.1

The Superintendent of the North Platte, Nebr., substation says in a recent publication:[a]

> A rotation that seems well adapted to our conditions here is as follows: Summer tillage, winter wheat, corn, spring grain, cane. Summer till and sow winter wheat; disk and fall plow the wheat stubble for corn the next year; disk the corn stubble for a spring grain—oats, wheat, or barley; apply manure during the winter, disk in the spring and plow for cane, which completes the rotation.

CLEARING THE LAND OF WEEDS.

Owing to its early maturity, barley is an excellent crop for clearing the land of weeds, as it is cut before they mature seed. After the crop is removed the land can be plowed or disked, thus destroying the weeds that are growing in the stubble. Further cultivation will kill any that survive this treatment or appear later. In the semiarid regions this added cultivation is of considerable value in conserving the moisture for the succeeding crop.

EFFECT OF BARLEY ON THE LAND.

Experiments conducted at the South Dakota station indicate that barley as a crop is exhaustive to the land. A crop of barley of 40 bushels or 1,920 pounds of grain and 2,200 pounds of straw removed from the soil 54.14 pounds of nitrogen, 20.93 pounds of phosphoric acid, and 49.35 pounds of potash, a total of 124.42 pounds. Comparing this with other crops, we find that a 30-bushel crop of corn, weighing 1,680 pounds, removed a total of 113.99 pounds of these three elements; a 15-bushel wheat crop, weighing 900 pounds, removed 59.11 pounds; and a 45-bushel oat crop, weighing 1,440 pounds, removed 97.77 pounds.

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[a] Bulletin 109, Nebraska Agricultural Experiment Station.

The comparative quantities of the elements removed from the soil by the grain and the straw of a 40-bushel barley crop were found to be as follows: Nitrogen, 28.99 and 25.15 pounds; phosphoric acid, 15.17 and 5.76 pounds; and potash, 9.22 and 40.13 pounds, respectively. From these figures it can be seen that the grain removed 1.1 times as much nitrogen and 2.5 times as much phosphoric acid as the straw. The straw, however, removed more than 4 times as much potash as the grain.

It has been estimated that under California conditions a 40-bushel crop of barley removes 46 pounds of nitrogen from the soil, or 1.15 pounds to the bushel. A 60-bushel crop of oats removes 55 pounds of nitrogen, while a 35-bushel crop of wheat removes 59 pounds. In South Dakota it was found that a 40-bushel crop of barley removed 1.35 pounds of nitrogen per bushel, or 0.20 pound more than in California.

ALKALI RESISTANCE OF BARLEY.

Experiments conducted by the California station demonstrated that barley is more resistant to alkali than wheat, as it withstood considerably more carbonate of soda and common salt. It was found that barley grew to a height of 4 feet in land containing more than 12,000 pounds of carbonate of soda per acre in the upper 4 feet, and produced 1 ton of hay per acre on a soil containing more than 5,000 pounds of common salt in the same depth. This station recommends that where the salt exceeds 5,000 pounds in the surface 4 feet, barley should be given the preference over wheat. In the irrigated district near Roswell, N. Mex., according to a correspondent, better results were obtained when winter barley was grown on alkali land before seeding to alfalfa.

DROUGHT RESISTANCE AND WATER REQUIREMENTS.

With the exception of the hooded and hull-less varieties, barley is not generally considered drought resistant. It is most affected when the plants are small and when the heads begin to fill. This accounts for the shortness of the straw following a dry spring and the poorly filled heads after a dry period during heading. The hooded and hull-less barleys will generally produce a crop with less rainfall than will spring wheats, with the possible exception of those of the durum type.

Experiments conducted by the Ontario Agricultural College demonstrated that the water requirements of the various small-grain crops at that place were: Wheat, 22.6 inches; oats, 21.15 inches; and barley, 18.52 inches. Previous to July 20, barley had used 2.25 times and oats 2.57 times as much water as had fallen in rain. The additional water necessarily came from the soil moisture.

At the South Dakota station the relative quantities of moisture needed to produce the various crops were determined. It was estimated that under the South Dakota conditions it required 464 tons of water to make 1 ton of dry matter of barley as compared with 271 tons for corn, 453 tons for wheat, and 504 tons for oats. It was estimated that corn used 4.63, oats 7.49, wheat 5.76, and barley 7.59 acre-inches of water. From the results obtained at this station barley was believed to be an exhaustive crop on soil moisture.

King, in his experiments at the Wisconsin station, estimated that under Wisconsin conditions it required 4.09 acre-inches of water to make 1 ton of dry matter of barley as compared with 4.44 acre-inches for oats and 2.39 acre-inches for corn. The Colorado station found that in that State barley required less moisture than oats.

PREPARATION OF THE LAND.

GENERAL STATEMENT.

Barley is grown over such a wide area and under such a diversity of conditions that definite rules for its cultivation can hardly be given. The thorough preparation of the seed bed is essential under all conditions, as on this depends a large part of the success of the crop.

Plowing should be done the fall previous or a considerable time before seeding. This allows a complete settling of the soil and improves its water-holding capacity. Many failures have resulted from planting barley on newly plowed ground, especially when a dry season followed. The crop seldom does well on newly broken sod; but when sod land is to be planted best results will be obtained if it is broken shallow and laid flat rather than set on edge, as is commonly done. Breaking should be done while the grass is fresh and green, as decomposition then sets in rapidly and the vegetation and roots soon decay. Plowing under vegetation when the plants and roots are tough is injurious, as their slow decay renders the soil too open.

No soil should be plowed when very wet. The shearing action of the plow upon the bottom of the furrow is likely to form an almost impervious layer or "plowpan" by compacting the soil particles. Unless the depth of plowing is varied from year to year this layer is likely to injure the growth of crops that follow. By gradually changing the depth of plowing each year new soil is brought to the top and mixed with the surface soil without injuring its yielding capacity.

In some portions of the United States the ground is seldom plowed for barley where it follows a cultivated crop, but is simply cross or double disked and harrowed. When the soil is in good physical condition good crops may be obtained by this method. A disk harrow in operation on corn ground is shown in figure 12.

PREPARATION IN THE EASTERN AND CENTRAL STATES.

Where possible, barley should follow a cultivated crop. As soon as the previous crop is removed in the fall the ground should be deeply plowed and left rough. As early in the spring as possible the land should be double disked, either crossing or lapping half. If the soil is rough and cloddy a plank drag (fig. 13) should be used to break the clods. In extreme cases a light roller should first be used. The disk harrow or plank drag should be followed by the smoothing harrow to make a fine seed bed. In a cold, backward spring this treatment will aid in warming up the soil.

If the land is not plowed until spring, the soil sometimes dries out so rapidly that it becomes hard before the plowing can be completed. If the land is disked as early as possible in the spring a mulch is formed that prevents excessive drying, so that the land remains in good condition for plowing for some time. The harrow should follow the plow as rapidly as possible, as this prevents the baking or hardening of the furrow slice. Further preparation should be the same as on fall plowing. Barley is frequently sown in this section on land which has been thoroughly disked but not plowed.

PREPARATION IN THE GREAT PLAINS AREA.

In the Great Plains area, where a most important factor in crop growth is the conservation of moisture, all soil preparation and cultivation should have that end in view. The land should be plowed in the fall and left rough, or plowed in the spring and backset in the fall. This allows the soil to absorb the winter rains and hold the snow, thus retaining the moisture which falls. The soil crumbles into a fine condition and does not pack as when smoothed with a harrow. It also blows less when left rough. In the spring the land should be double disked, lapping half, thus making a comparatively level surface. The harrow should follow the disk in order to form the mulch so essential to the conservation of moisture.

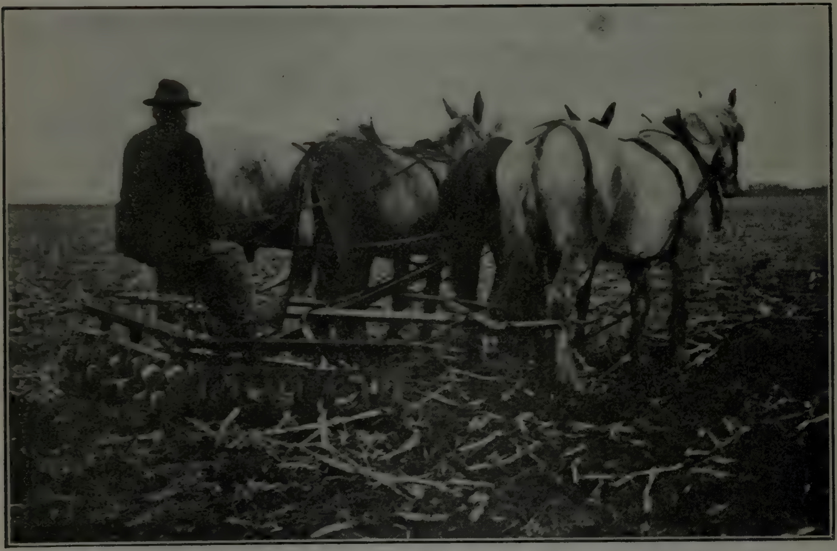

FIG. 12.—The cutaway disk harrow as it is used in the preparation of corn land for small grain.

In portions of the West it may be necessary to subsoil and to use implements to pack the subsurface. A corrugated roller, a heavy disk harrow with the disks set straight, or a heavy spike-tooth harrow can be used to advantage for crushing clods and packing the soil. A common smooth roller is apt to make the soil too compact unless it is followed immediately by the harrow to loosen the surface.

In some portions of the Great Plains it is believed best to leave the stubble unplowed until early spring, in order to hold the winter snows and prevent the blowing of the soil. There is danger, however, when plowing is not done until spring, that unfavorable weather conditions may delay seeding.

PREPARATION IN THE PACIFIC STATES.

Barley in the Pacific States is sown in both winter and spring, depending on the locality and season. The preparation of the soil varies with the method and time of seeding.

In California, in the valleys subject to overflow, barley is sown late in the spring. The land should be plowed deep and the plow followed immediately by the harrow, so that a good firm seed bed may be prepared. When the land is plowed and the seed sown in the same operation, the harrow should follow to make a good seed bed. Where barley is sown after wheat as a winter crop, the wheat stubble should be double disked as soon as the crop is removed. This breaks down the stubble, covers the weed seeds, and renders the soil receptive to the fall rains. Immediately following the fall rains the land should be rather deeply plowed and well harrowed.

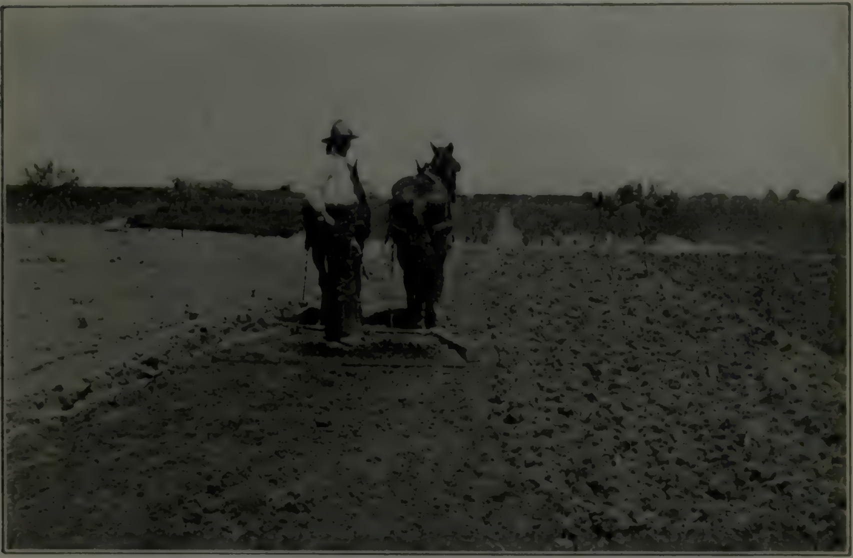

FIG. 13.—A plank drag, a useful tool in preparing the seed bed for barley.

In some localities it is occasionally desirable to summer-fallow for barley, in order to clean the land of weeds or to rest it after a long period of continuous cropping. When the land is foul with weeds, the method of cleaning practiced upon the experimental farms of the Department of Agriculture in California has given excellent results. Immediately after the removal of the previous crop the land is disked and harrowed. After the fall rains, when the weed seeds are well germinated, the land is plowed to a depth of 4 inches and immediately harrowed. After the winter rains the land is plowed to a depth of 8 inches, in order to bring to the surface the weed seeds not exposed during the previous plowing, and is again harrowed. During the summer the land is kept free from weeds by occasional cultivations. At seeding time in the fall or winter the land is deeply disked, the seed sown, and the land harrowed as rapidly as sown. To obtain the best results the land should be harrowed just before the barley comes up, in order to kill the last crop of weeds.

Where land is fallowed it is usually plowed deep and a surface mulch maintained by the occasional use of the harrow, which prevents a crust from forming and destroys the young weeds. The land is again harrowed just before seeding. This method has many advocates, as it requires less labor than the one just described.

Another method successfully used by a number of farmers in the semiarid portions of Washington is adapted to a large area in the Pacific Northwest, where conservation of moisture is necessary. The land is deeply plowed in the fall and left rough. This deep plowing is less expensive in the fall, when other work is less urgent, than in the spring. The plowing also destroys a large number of weeds, and the loose soil absorbs and stores the moisture from the winter snows and rains. As early in the spring as possible, when the young weeds and volunteer grains appear, the land is plowed shallow, not more than half the depth of the fall plowing, and immediately well harrowed. This shallow plowing is light work for the team, and the land can rapidly be prepared for seeding. The harrowing kills a large number of young weeds and forms a mulch which conserves the soil moisture.

PREPARATION FOR WINTER BARLEY.

Where winter barley is grown various methods of soil preparation are followed. A common method is to sow it after a cultivated crop for which the land has been manured and plowed. Where barley follows corn, the corn is cut and removed from the field or placed in large shocks in straight rows. The ground is then deeply disked both ways and harrowed, thus obtaining a good surface and a firm seed bed. Where winter barley follows early potatoes or a grain crop, as soon as these crops are removed the land should be plowed shallow or disked deep and harrowed. By continuing the cultivation throughout the summer a mellow seed bed free from weeds is obtained and the mulch formed retains the moisture in the soil. A shallow disking and cross harrowing before planting insures a perfect seed bed. On the compact clay soils of the Eastern and Southern States excellent crops of winter barley can be grown after cowpeas turned under the latter part of August. If lime has not been applied for several years, an application of 20 to 25 bushels per acre should be made. This should be thoroughly mixed with the soil, either by drilling or by means of the disk and smoothing harrows. In dry seasons, when the soil is cloddy, the clods may be crushed by the corrugated roller followed by the plank drag. If the smoothing harrow is then used an excellent seed bed is formed. The use of the disk drill in seeding still further improves the surface soil.

EFFECT OF SOIL TREATMENT ON THE YIELD.

At the Pennsylvania station six different methods of soil preparation were tried in duplicate. In three of the methods the soil was plowed, while in the remaining three it was simply cultivated. Manchuria (Mansury) barley was sown on all the plats at the rate of 8 pecks per acre. The average yields of grain and of straw obtained from each of the methods of soil preparation are given in Table III.

TABLE III.—*Yields of barley, both grain and straw, at the Pennsylvania station*[a] *with different methods of soil preparation.*

Method of soil preparation.	Average yield per acre.	
	Grain.	Straw.
	Bushels.	*Pounds.*
1. Plowed 7 inches deep and rolled	21.8	980
2. Plowed 7 inches deep and harrowed 3 times, ordinary conditions	21.7	1,240
3. Plowed 7 inches deep, harrowed 3 times; seed bed finely pulverized	21.2	935
4. Not plowed; harrowed twice, surface but slightly disturbed	15.7	1,090
5. Not plowed; cultivated once with 8-shovel corn cultivator and harrowed once; surface rather poorly pulverized	15.1	850
6. Not plowed; cultivated 3 times with 8-shovel corn cultivator and harrowed 3 times; surface soil fairly well pulverized	17.9	1,020
Average plowed	21.6	1,051
Average not plowed	16.2	987
Increase due to plowing	5.4	64

[a] Annual report for 1891, p. 48.

The yield on the plowed plats was considerably larger than that on the unplowed, but no advantage was derived from additional labor expended in either case over the plat which was plowed and harrowed three times. Similar results were obtained in experiments conducted at the Utah station, where excessive cultivation reduced the yield.

Table IV gives the yield in bushels to the acre as the result of one year's trial of barley in Kansas, at the Fort Hays Branch Experiment Station, with different methods of soil preparation. The land in these experiments was all plowed alike and the conditions were similar, with the exception of the later treatment.

TABLE IV.—*Yield of barley at Hays, Kans., with different methods of soil preparation.*[a]

Number of acres.	Treatment.	Date.		Yield per acre.
		Planted.	Cut.	
				Bushels.
7	Harrowed once after plowing	Mar. 30	July 15	28.12
7	Packed after plowing	...do	July 16	30.01
7	Harrowed and packed after plowing	...do	July 18	29.35
7	Harrowed and disked after plowing	Mar. 28	...do	30.35
7	Not treated after plowing	...do	July 19	26.08

[a] Bul. 128, Kansas Agricultural Experiment Station.

The highest yield, as shown in the table, was produced on the field which was both harrowed and disked after plowing, though packing after plowing gave nearly the same results. These two treatments each produced yields 4 bushels higher than that of the untreated field, while all the treatments resulted in some increase in yield. Too much emphasis, however, should not be placed on the yields obtained from the different treatments, as it requires a number of years' trial to demonstrate which is the most profitable method of soil treatment in any locality.

Chilcott[a] gives the average yield of barley obtained in 1907–1909 from various methods of tillage at 11 different stations in the Great Plains area, located in Montana, North Dakota, South Dakota, Colorado, Nebraska, Kansas, and northern Texas. Where the land was continuously cropped under ordinary methods, the average yield obtained was 21.11 bushels; where the cropping was continuous, but moisture-conservation methods were practiced, 22.88 bushels; and where alternate cropping and summer tillage were practiced, 30.74 bushels. While summer tillage increased the yield of barley, and in seasons of drought would prevent failure, under ordinary conditions the increased cost due to plowing, disking, and harrowing proved too expensive for the increased results obtained.

SOWING THE SEED.

Kind of seed to sow.—The proper selection of barley for seed is important, but is a factor in the production of the crop which is often neglected. Where the grain is very small or imperfect the vitality is generally poor. Even though these small grains germinate, the plants produced are weak and may not survive an unfavorable season. If they mature, they generally produce grain of inferior quality. The lateral grains in the six-rowed barley during unfavorable seasons are light and chaffy and will not germinate, hence they should be removed and only plump seed sown. The stand will be considerably improved by the removal of this inferior seed. It is generally true that large, plump seeds contain larger germs than small ones and produce stronger and more vigorous plants, which rapidly develop large, healthy root systems. This rapid development of the root systems aids them to resist drought or other unfavorable conditions. Where a well-established root system is developed early in the growth of the plant, the maximum quantity of moisture and plant food for its successful development is supplied. On the Great Plains, where barley is injured by the blowing of the soil, a plant with a strong root system can better retain its hôld than a weak-rooted one.

Testing the germination.—If, owing to unfavorable weather conditions during the ripening period or after harvest, the seed is of doubtful viability, several lots of 100 grains each should be taken from different parts of the seed bin and tested in plates of moist sand or earth, or between sheets of moist blotting paper. If less than 90 grains of each lot show vigorous germination, better seed should be obtained or the quantity of seed sown per acre increased.

Time of seeding.—Barley should be sown as soon as danger from severe frosts is over and the soil is sufficiently warm and dry to prepare a good seed bed. This date varies in the Northern States from April 1 to May 15, according to the locality and season. In the central portion of the United States planting begins as early as March 1 and continues until the middle of April. In the Southern and Central States where winter barley is sown, seeding between September 15 and

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[a] Chilcott, E. C. A Study of Cultivation Methods and Crop Rotations in the Great Plains Area. Bulletin 187, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1910.

October 15 gives best results. Where the crop is liable to attack from insects, October 1 to 15 is preferable. If intended for pasture, however, the seeding should be done early in August. In the Southwestern States seeding is most successful when done in November, December, and January. In California the seeding of barley extends from November to March, according to the elevation, location, and season.

At the Kansas station, in 1905 and 1906, experiments were conducted on the seeding of barley on various dates. In 1905 seeding began on March 10 and was continued on March 14 and 30, April 13, 20, and 27, and May 6 and 12. The seeding of March 30 gave the best yield, 25.69 bushels, while that of May 12 gave the lowest yield, 6.64 bushels, only about one-fourth as much as the seeding of March 30. In 1906 the experiment was repeated, the seeding beginning February 1. Seed was also sown February 19, March 29, April 10, 21, and 28, and May 11. Owing to favorable weather conditions the seeding of February 1 gave the largest yield, 36.55 bushels, and that of February 19 the next highest, 30.21 bushels, while the lowest yield obtained, 5.83 bushels, was from the seeding of May 11. In general, however, seeding as early as February is not advisable in Kansas.

Rate of seeding.—The rate of seeding depends on the rainfall, the fertility of the soil, and the variety. In the humid regions seeding at the rate of 8 pecks to the acre gives the best results, while in the semiarid regions of the West and Southwest 4 to 6 pecks are sufficient. Thick sowing, even under ideal conditions, while it produces a heavy stand, does not always give the best results, as when the plants are crowded there is a tendency for the grain produced to be small.

At the North Platte, Nebr., substation, 4 varieties of common barley were sown at 4 different rates, 2, 4, 6, and 8 pecks per acre, on two different dates in 1907, March 20 and April 3, and on one date in 1908, April 6. The highest average yield for the three dates of seeding was obtained from the 6-peck rate. With the hull-less barley sown on the same dates at the rates of 2, 4, and 6 pecks to the acre, the 4-peck and 6-peck rates gave practically the same yields, about 2.5 bushels more than the 2-peck rate.

Method of seeding.—The best method of sowing barley is in drills 6 or 8 inches apart (fig. 14). This method insures even distribution of the seed and places the grain at the proper depth for germination, thus promoting a perfect stand. Grain in drills can withstand a dry season better than that sown broadcast, as the plants develop a deeper root system, enabling them to absorb more plant food and moisture from the soil. Where the crop is drilled there is a better opportunity for air and sunlight to penetrate, an important factor during a moist season. When barley is sown broadcast and harrowed in, it is covered to various depths and germinates unevenly. While a good stand may be obtained, the plants from seed not sufficiently covered frequently fail to survive a long dry period following spring sowing, or a severe winter after fall sowing.

At the North Platte, Nebr., substation, drilled barley yielded 27.7 bushels to the acre, while that sown broadcast gave a yield of only 17.7 bushels, an increase of 10 bushels in favor of drilling. As the season was dry, the drilled barley germinated quicker and made a better stand than that sown broadcast. In an experiment conducted by the Wyoming station at five substations, at elevations ranging from 4,000 to 7,200 feet, it was found that barley sown in 8-inch drills, 1 inch apart in the row, gave the largest yields.

Depth of seeding.—Little attention is generally paid to the depth at which barley is sown. It varies from a fraction of an inch when sown broadcast to several inches when sown with a drill. The proper depth depends on the moisture and the physical condition of the soil. Usually, seeding at a depth of 2 to 3 inches will give best results. On compact soils the former depth is sufficient.

In an experiment at the North Dakota station[a] in seeding barley at depths varying from 1 inch to 4½ inches, it was found that seeding at a depth of 3 inches gave the best results. In an experiment at the Minnesota station in seeding barley at different depths from one-half inch to 3 inches it was found that the highest yield of grain and straw was obtained from seeding at depths of 1 to 2 inches. The deeper seeding required one day longer to mature. In another experiment at this station it was found that barley covered to a depth of 1 inch or less germinated better and tillered more than that planted deeper. In still another test the seed was sown at depths ranging from three-fourths of an inch to 3½ inches. The shallowest planting gave the largest yield of straw, 2,120 pounds, but the smallest yield of grain, 24.5 bushels, while the deepest planting gave a yield of 1,770 pounds of straw and 31.9 bushels of grain.

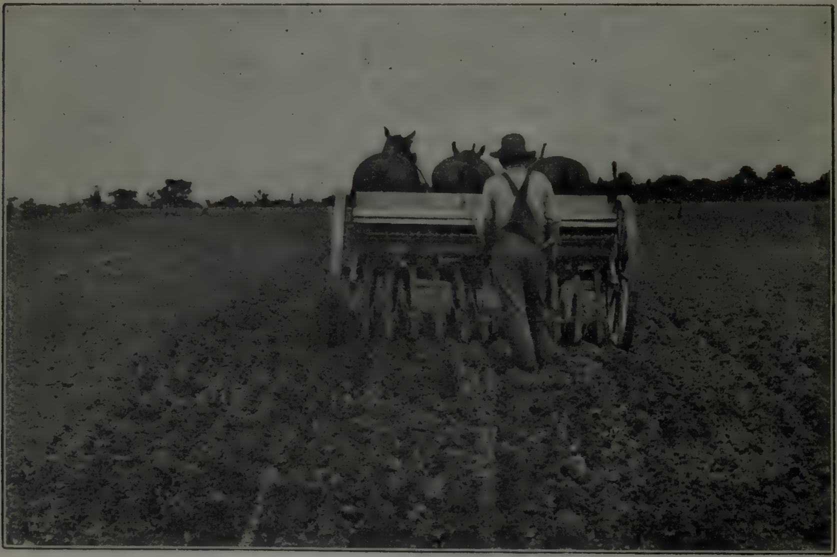

FIG. 14.—A grain drill and a well-prepared seed bed, two important factors in barley culture.

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[a] Bulletin 39, North Dakota Agricultural Experiment Station.

TREATMENT AFTER SEEDING.

CULTIVATION.

Barley, as a rule, is not cultivated, though in the semiarid regions or in seasons of drought in the more humid ones barley sown in drills will be benefited by cultivation with a spike-toothed harrow or weeder. This loosens the surface soil, aids in holding the moisture, and destroys small weeds. Barley sown broadcast, however, can not be cultivated without considerable loss.

In an experiment at the Akron, Colo., substation, two plats were sown to barley in 8-inch and 12-inch drills. The same rate of seeding per row was used. One plat of each width of planting was cultivated with a harrow, while the other was not. The cultivated plat in 8-inch drills yielded 1.2 times as much straw and 1.4 times as much grain as the uncultivated plat. The cultivated plat in 12-inch drills yielded 1.5 times as much straw and grain as the uncultivated plat. The plants on the cultivated plats were 2 to 3 inches taller than those on the uncultivated ones. On the experiment farms at Modesto and Ceres, Cal., fields of barley were harrowed just before the grain came up, and many weeds were killed by this cultivation. After the winter rains were over the cultivation was continued after every shower until the grain was so high as to be injured by the harrow. These harrowings were of much benefit to the growing grain. At the Highmore, S. Dak., substation, the harrow is used to preserve the soil mulch before the plants appear. After the plants are an inch or more in height the weeder is used until the grain is 6 inches high. This treatment is efficient in destroying a large number of weeds as well as in conserving the moisture. At the Wyoming station a thorough harrowing to break the soil crust and conserve the moisture is considered an excellent practice during early growth.

IRRIGATION.

In the Rocky Mountain States considerable barley is grown under irrigation. The proper quantity of water to apply to obtain the best results is a question of considerable importance.[a] Where the supply is abundant, farmers are apt to use more water than is necessary. Surface indications are not safe guides to follow in the irrigation of barley, as a soil may appear to be dry on the surface and yet contain sufficient moisture for the growth of the crop.

The Nevada and Wyoming stations have conducted numerous experiments in the irrigation of barley, and valuable data have been obtained. In experiments at the Nevada station in the past two years some plats were given what was considered an excessive quantity of water, and others an insufficient supply. Table V gives the number of irrigations, depth of water applied, and the yield produced.

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[a] A thorough discussion of the proper use of water for the irrigation of grain crops can be found in Farmers' Bulletin 399.

TABLE V.—*Yield of barley obtained from no irrigation and from one and two irrigations, and the application of various depths of water at the Nevada station in 1908 and 1909.*

Number of irrigations.	Depth of water in feet.	Yield per acre.		Yield per acre-foot of water.	
		Pounds.	Bushels.	Pounds.	Bushels.
2	0.843	1,432	29.84	1,700	35.40
2	.832	1,892	39.43	2,280	47.40
1	.386	1,677	34.95	4,360	90.60
1	.579	1,127	23.49	1,940	40.57
None		1,080	22.50		

This table shows that the excessive application of water in irrigation gave a much lower yield than where a moderate quantity was used, and that no irrigation gave almost as good a yield as where an excessive supply was given in one irrigation. The yield per acre-foot from one moderate irrigation was much greater than that from two irrigations.

In a series of experiments at the same station on the quantity of water necessary to produce farm crops, water was applied from 2 to 8 times to the barley crop. The largest yield, 58.5 bushels, was obtained from 2 irrigations, and the application of water to a depth of 0.99 foot. The barley irrigated 8 times, with a total application of 1.34 feet of water, yielded only 33.8 bushels. Barley not irrigated yielded 34 bushels, or slightly more than that irrigated 8 times. The conclusion arrived at was that in ordinary practice fully twice as much water is applied as is required for best results with barley.

Experiments in the irrigation of barley at the Wyoming station showed that this crop varies in yield and quality according to the quantity of water applied. The highest yield was harvested from the plats receiving 16 to 20 inches of water, applied in 3 irrigations. The quality for brewing purposes was injured by the application of too much water. The most satisfactory method of irrigation was by means of furrows 16 inches apart, as compared with the flood and check methods. The first cost was higher, but the labor of later irrigations was less than with either of the other methods. In a number of experiments conducted at different stations throughout the State the beneficial effects of irrigation were noticeable in the increased tillering and in the number of large, well-matured heads. In every case the increased yield demonstrated the value of irrigation over the nonirrigated plats.

HARVESTING THE CROP.

Time to harvest.—Barley ripens in the Southern States from May 1 to June 1. In the Central States it generally matures in June and July, and in the Northern States in July and August. In the Pacific States the time of ripening varies from May 15 to September 1, according to the elevation and the time of seeding. Unfavorable weather conditions may extend the season, but usually a few days' difference in seeding causes but a slight variation in the time of ripening.

Barley requires more judgment in harvesting than almost any other cereal. If harvested too early the appearance and value of the grain are injured by shrinkage. If allowed to become overripe the heads bend over and shatter badly during harvesting, while in humid regions the grain becomes discolored.

The hardness of the grain when pinched between the thumb and first finger will indicate when the crop is ready to harvest. If the grain can just be dented with the nail, it is in the hard-dough stage and should be cut immediately. In unfavorable seasons, when the grain ripens unevenly, it is better to cut when most of the heads are ripe, even though there is some loss from shrinkage. If the grain is intended for brewing purposes it should not be cut too early, as it increases in value until the grain is dead ripe. Barley should not be cut when wet with dew or rain, as the bundles dry out slowly. At the Maryland station grain of better color and higher weight per bushel was obtained when cut when the straw was all ripe and the grain in the dough stage than from earlier or later cutting.

Method of harvesting.—Barley is usually harvested with the binder. In the semiarid region the header is sometimes used, and in the Pacific and Rocky Mountain States the combined harvester, though in some seasons the straw is too short for the use of either of these machines.

In dry seasons when the straw is short it can sometimes be cut with the binder by lowering the platform and lowering and tilting the reel. Where this is not practicable, the crop can frequently be cut to advantage with the mower. In this case it should be harvested before it is fully ripe in order to prevent shattering from the trampling of the horses. The grain cures readily, and can be bunched with the horserake with little loss. Cocks can then be made which, if carefully topped, will shed water quite readily.

Shocking and stacking.—If weather conditions are favorable, it is best to let the bundles dry before shocking. They should then be set up in oblong rather than round shocks, as the oblong shocks allow better ventilation. Capping the shocks is usually practiced, but they should not be capped when wet. In sections of the West where high winds prevail, barley is usually shocked without capping, as the caps blow off and the quality of the grain in such sheaves is injured by lying on the ground.

Barley while in the shock is frequently injured by heavy rains. Moisture not only discolors the grain, but if excessive may also cause it to sprout. Opening the shocks is the only remedy. The common method is to scatter the bundles on the ground, but as there is danger that the grain in contact with the soil will absorb sufficient moisture to cause further injury, the method practiced in Germany and by farmers in some localities in the United States is recommended. When the shocks are opened the first bundle is laid flat on the stubble; the second and succeeding bundles are then laid across the middle of the preceding ones, the butt ends resting on the ground and the heads projecting beyond the bundles upon which they rest, the object being to keep the grain off the ground. By lapping the bundles in this way (fig. 15) the heads are kept off the ground and are exposed to the action of the air, so that they dry out quickly. Even though rained on while in this position, they will soon dry and will be damaged less than if lying on the ground.

Barley should not be stacked until the grain has at least partly cured in the shock, especially when the bundles contain weeds or grass. Insufficient curing in the shock may cause heating, discoloration, and germination during the sweating process in the stack. If the grain is fully ripe when cut it can be stacked in a few days. In the semiarid regions some growers stack as soon as the crop is cut.

The general opinion among the most successful growers in the West is that stacking gives better results both in color and soundness, two important factors in regulating the price of barley. Barley is generally more difficult to stack than wheat or oats because of the shortness of the straw. As it does not shed water as readily as wheat or oats, it is better to stack in slender, circular stacks, rather than in the extremely large ones commonly seen in the West.

Shock thrashing versus stack thrashing.—Considerable difference of opinion exists as to the relative merits of thrashing from the shock and from the stack. The difference in cost is usually the deciding factor. On the smaller farms, where practicable, stacking after curing in the shock is unquestionably the best method, as a better quality of grain is produced. On the larger farms, where the crop is grown on an extensive scale, the thrashing is generally done from the shock. The comparative cost of thrashing barley from the stack and from the shock was carefully computed in Minnesota. In Norman County the cost of thrashing from the shock was 4.4 cents per bushel, and of stacking and thrashing, 5.4 cents. In Rice County thrashing barley from the shock cost 4.8 cents per bushel, and from the stack, 5.9 cents. While the cost of thrashing from the stack is generally 1 or 2 cents a bushel more, many farmers prefer to stack on account of the better color and quality of the grain. A thrashing scene in Minnesota is shown in figure 16.

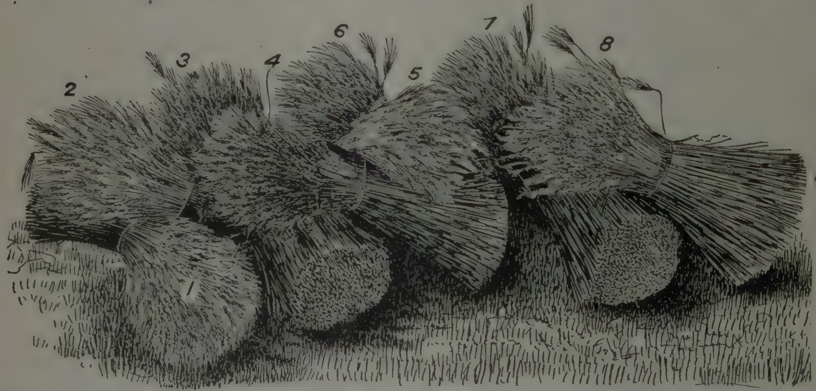

FIG. 15.—Method of laying wet bundles to dry in order to prevent the sprouting of the grain. The numbers indicate the order in which they are laid.

Thrashing.—If the grain stands in the shock for some time, the cap sheaves often become discolored from rains or heavy dews. If these are thrashed with the bundles which have been protected, the discolored kernels will be mixed with the brighter grain and the market value of the whole lessened. If the cap sheaves are thrashed separately the discolored grain may be kept for feeding on the farm, as color does not materially affect the feeding value; but when barley is long exposed to the weather some loss is occasioned by the leaching out of some of the soluble constituents of the grain.

Care should be used in thrashing. If the concaves are set too close many grains will be cracked or broken and the awns will be broken off too close to the grain, thus considerably reducing its viability and market value.

STORING THE GRAIN.

Barley should be carefully housed after thrashing, as it rapidly absorbs moisture and is easily influenced by changes in temperature. If stored in damp bins it becomes musty, and as odor is one of the factors which influence the market value, dampness and mustiness should be avoided. Dampness is also likely to injure the germination of the grain, either for malting or for seed. When barley is well cured before thrashing and is stored in cool, dry bins, it passes through the sweating process and remains bright, clean, and sweet. If the grain becomes damp in any way it should be shoveled over several times or changed to another bin in order to dry it thoroughly. A prominent grain grower in Maryland dries damp or poorly cured grain by forcing a current of air through it from the bottom of the bin by means of a fan driven by a small engine. The fan is usually run for a day or two, but after the current is established the fan can be stopped. This method avoids the necessity of rehandling the grain when it becomes damp.

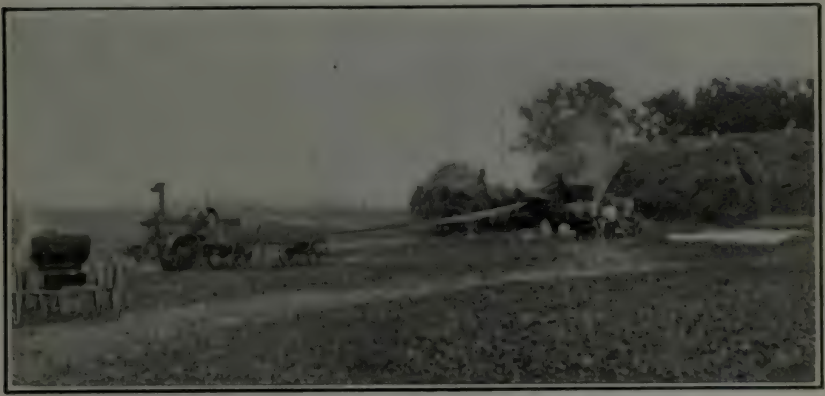

FIG. 16.—Thrashing barley from the shock in Minnesota.

VARIETY TRIALS.

RESULTS OF EXPERIMENTS IN DIFFERENT STATES.

Experiments in the cultivation of barley in the United States have been conducted for many years, but it is only recently that definite results have been obtained or accurate data collected. Many varieties are now grown at the various experiment stations and farms, in order to determine those best adapted to the different localities. The results of some of these variety trials are reported in the following pages.

TRIALS IN THE EASTERN, CENTRAL, AND SOUTHERN STATES.

Experiments conducted at various places in the States of New York, Pennsylvania, Ohio, Indiana, and Illinois indicate that the six-rowed varieties of barley are the most profitable. Definite results have been reported in only a few instances. In Maryland, Virginia, Kentucky, and Tennessee, and in the southern portions of Ohio, Indiana, and Illinois the six-rowed winter barley gives excellent results.

TRIALS IN THE NORTH CENTRAL AND PLAINS STATES.

Wisconsin.

At the Wisconsin station a large number of varieties of barley have been tested. Of late years, however, only four pedigreed six-rowed varieties have been extensively grown. These are Oderbrucker, Manchuria, Silver King, and Golden Queen, which rank in yield in the order given. The average yield of Oderbrucker for the 5-year period from 1905 to 1909 was 51.2 bushels; of Manchuria, 46.2 bushels; of Silver King, 41.9 bushels; and of Golden Queen, 32.3 bushels. The average number of days required to mature these varieties was ninety-four, and the average weight per bushel 45 to 47 pounds. Oderbrucker barley has been extensively distributed throughout the State. Its high yielding power has put Wisconsin in the front rank as a barley-producing State.

Minnesota.

At the Minnesota station the six-rowed barleys yield best. The average of the 10 best six-rowed varieties in 1908 was 43.7 bushels, while the 10 best two-rowed averaged but 36.3 bushels. The Manchurian barleys are at their best in that portion of the State, several selections yielding 45 to 50 bushels per acre. Among the best two-rowed varieties are Frankish Brewing and several selections of Chevalier, which averaged yields of 37 to 41 bushels.

North Dakota.

Table VI gives the average yield of the varieties of barley grown at the North Dakota station from 1902 to 1907, with the average number of days each required to mature. The 1905 crop is not included in the averages.

TABLE VI.—*Average yields of 10 varieties of barley and the average time each required to mature at the North Dakota station, for five years, 1902, 1903, 1904, 1906, and 1907.*

Name of variety.	Group.	Yield per acre.	Time to mature.	Name of variety.	Group.	Yield per acre.	Time to mature.
		Bushels.	*Days.*			*Bushels.*	*Days.*
Russian	Six-row	42.7	84	Great Beardless	Six-row	32.3	81
Common	...do	42.5	83	Moravian	Two-row	40.4	85
Silver King	...do	40.0	84	Highland Chief	...do	37.3	95
Manchuria	...do	40.3	82	Mansury	...do	37.0	94
Barnards	...do	38.3	84	McEwans	Hull-less	34.5	83

From these trials it appears that there is little difference in the yields of the six-rowed and two-rowed barleys in eastern North Dakota. In 1908, however, a number of pedigreed two-rowed barleys were sown, which considerably outyielded the best six-rowed varieties. The yields were: Hannchen, 67 bushels; Chevalier, 66 bushels; Primus, 64.6 bushels; Hanna, 56 bushels; Princess, 47.3 bushels; with an average of 60 bushels for the five pedigreed varieties. Russian, the leading six-rowed barley in the table, yielded 52.7 bushels to the acre in 1908, or 7.3 bushels less than the average for the pedigreed two-rowed varieties.

Barley has been grown at the Edgeley, N. Dak., substation since 1904. In a 6-year trial, from 1904 to 1909, a two-rowed variety gave an average yield of 37.42 bushels to the acre, 3.83 bushels greater than the best six-rowed variety. In the three years from 1907 to 1909, however, there was little difference in yield between the two-rowed and six-rowed barleys. The Blue Ribbon, New Moravian, Manchuria (Minn. No. 105), and White Hull-less varieties were grown during this period. In the 3-year average Blue Ribbon led, with a yield of 28.4 bushels. A large number of varieties were tested in 1908 and 1909; the best of them are grouped in Table VII, according to type and rank in yield. The average number of days each required to mature is also given. In this 2-year test the two-rowed varieties yielded slightly better than the six-rowed. The highest yielding two-rowed variety was Black Smyrna, with an average yield of 40.9 bushels to the acre.

TABLE VII.—*Annual and average yields of 18 varieties of barley and the average time each required to mature at the Edgeley, N. Dak., substation, 1908 and 1909.*

Name of variety.	Group.	Yield per acre (bushels).			Days to mature.
		1908.	1909.	Average.	
Black Smyrna	Two-row	40.80	41.00	40.90	92
Smyrna	do	38.70	41.00	39.85	92
Hannchen	do	32.40	33.60	33.00	97
Hanna	do	30.30	41.40	35.85	95
Bohemian	do	30.30	31.90	31.10	95
Bavarian	do	30.30	30.10	30.20	97
Swan Neck	do	28.20	30.50	29.35	97
Odessa	Six-row	44.30	33.60	38.95	99
Gatami	do	31.70	42.80	37.25	95
Mariout	do	30.30	43.20	36.75	92
Golden Queen	do	35.90	30.00	32.95	95
Manchuria	do	31.60	33.90	32.75	96
Summit	do	28.20	35.20	31.70	97
Oderbrucker	do	25.40	32.50	28.95	93
Boehme's Hull-less	Hull-less	26.50	30.70	28.60	94
Black Hull-less	do	21.40	31.70	26.55	93
White Hull-less	do	20.80	31.00	25.90	94
Do	do	20.30	29.80	25.05	94

At the Dickinson substation the two-rowed barleys far outyielded the six-rowed type in 1908 and 1909. The leading varieties in this trial were the Hannchen, the Swan Neck, and the Chevalier II, with average yields of 43.15, 42.13, and 40.97 bushels to the acre, respectively. The highest yielding variety of the six-rowed type was the Gatami, with an average yield for the two years of 29.66 bushels.

The average for Hanna for the three years 1907–1909 is 40.10 bushels to the acre; Imperial, 34.36 bushels; Gatami, 31.99 bushels; Manchuria, 24.87 bushels. The yields of 7 two-rowed and 4 six-rowed varieties for the years 1908 and 1909 are shown in Table VIII.

TABLE VIII.—*Annual and average yields of 11 varieties of barley, showing average weights per bushel and the average time required to mature at the Dickinson, N. Dak., substation, 1908 and 1909.*

Name of variety.	Group.	Yield per acre (bushels).			Pounds per bushel.	Days to mature.
		1908.	1909.	Average.		
Hannchen	Two-row	37.50	[a]48.80	43.15	52.25	104
Swan Neck	do	39.37	44.90	42.13	49.00	103
Chevalier II	do	36.15	45.80	40.97	51.50	107
Hanna	do	28.54	39.89	34.21	50.50	108
Princess	do	32.71	38.50	35.60	50.00	109
Imperial	do	28.33	40.40	34.36	51.50	109
Primus	do	29.27	36.70	32.98	51.75	106
Gatami	Six-row	31.42	27.90	29.66	48.75	103
Oderbrucker	do	22.08	30.00	26.04	48.25	100
Manchuria	do	27.92	30.20	29.06	48.75	103
Hull-less	do	17.66	19.20	18.43	62.25	105

[a] Average of three check plats.

At the Williston substation a number of varieties of barley have been grown for the three years 1908–1910, on land which had not previously been cropped. The results of these trials are shown in Table IX. The yields in 1908 and 1910 were low, owing to lack of moisture, while the high yields of 1909 were caused by favorable weather conditions, as the soil and its preparation were similar in all three years.

TABLE IX.—*The annual and average yields of 13 varieties of barley at Williston, N. Dak., substation, for 1908, 1909, and 1910.*

Name of variety.	Group.	Yield per acre (bushels).			
		1908.	1909.	1910.	Average.
Manchuria (Minnesota No. 6)	Six-row	15.7	57.0	8.1	26.9
Common	do	18.2	53.7	6.1	26.0
Bernard's	do	17.1	52.1	5.7	25.0
Silver King	do	12.0	57.2	4.7	24.6
Russian	do	11.3	57.8	3.9	24.3
Manchuria (Minnesota No. 105)	do	14.3	49.4	6.7	23.4
Manchuria	do	13.3	53.5	4.5	23.7
Minnesota No. 32	do	13.7	50.3	3.8	22.6
Minnesota No. 87	do	9.8	51.3	2.6	21.2
Moravian	Two-row	10.0	56.0	3.9	23.3
Mansury	do	6.4	56.0	2.0	21.5
Highland Chief	do	10.6	47.8	2.4	20.3
Success	do	11.3	46.0	1.2	19.5

Table IX shows that of the varieties tested the six-rowed were superior to the two-rowed. The highest yielding variety in the 3-year test was Manchuria, a six-rowed variety, with an average yield of 26.9 bushels to the acre for the three years. Common and Bernard's, both six-rowed varieties, ranked second and third in this test. The average yield of the 7 six-rowed varieties for the three years was 24.2 bushels, and of the 4 two-rowed 21.1 bushels.

South Dakota.

Table X gives the average yields of the best varieties of barley grown at the South Dakota station at Brookings during the five years 1905 to 1909, inclusive. The range in number of days from planting to maturity during the period is also given. The hull-less barleys matured from two to six days earlier than the other varieties and the six-rowed from four to six days earlier than the two-rowed kinds.

TABLE X.—*Average yield of 11 varieties of barley, and the time required to mature, at the South Dakota station for five years, 1905–1909.*

G. I. No.	Name of variety.	Group.	Average yield per acre.	Time to mature.
			Bushels.	*Days.*
187	Swan Neck	Two-row	43.50	96–102
	Chevalier	...do	41.21	96–105
24	Hanna	...do	40.66	94–105
	Hannchen	...do	39.55	94–103
182	Odessa	Six-row	43.91	90–101
	Manchuria (Minnesota No. 6)	...do	40.54	90–101
170	Manchuria	...do	38.28	90–101
184	Common	...do	38.22	90–99
336	Grecian	...do	36.98	90–102
22	Hull-less	...do	26.07	88–101
335	Little Blue Hull-less	...do	22.19	94–104

In the trials at this station there has been little difference in the yields of the two-rowed and the six-rowed groups. The highest average yield for the five years, 43.91 bushels to the acre, was obtained from a six-rowed variety, the Odessa, while the Swan Neck, a two-rowed variety, ranked second with 43.50 bushels. Other leading two-rowed varieties were Chevalier and Hanna, while Manchuria (Minnesota No. 6) ranked next to Odessa among the six-rowed kinds.

Table XI gives the 5-year and 7-year average yields of the best varieties of barley at the Highmore substation, arranged according to type and rank in yield.

TABLE XI.—*Average yield of 10 varieties of barley at the Highmore, S. Dak., substation for periods of five to seven years.*

G. I. No.	Name of variety.	Group.	Average yield per acre for period (bushels).	
			Five years (1905–1909).	Seven years (1903–1909).
531	Hannchen	Two-row	33.9	....
27	Bohemian	...do	33.0	27.7
530	Chevalier	...do	32.4	....
24	Hanna	...do	32.1	28.2
203	....do	...do	32.1	27.1
34	....do	...do	31.9	26.6
32	Bohemian	...do	31.2	26.4
31	Horn	...do	29.0	24.6
532	Primus	...do	27.1	....
....	Manchuria (Minnesota No. 6)	Six-row	28.3	26.5

In the 7-year period the Manchuria (Minnesota No. 6) six-rowed has yielded nearly as well as the two-rowed barleys. In the 5-year average, however, the two-rowed barleys considerably outyielded the six-rowed. The Odessa and the Manchuria (Minnesota No. 105), both six-rowed varieties, which have been grown only four years, have yielded less than the Manchuria (Minnesota No. 6). · From the results obtained during the seven years' trial it is evident that the two-rowed varieties are better adapted to the central section of the State than the six-rowed. In 1909 the length of the ripening period ranged from 75 to 86 days, the Odessa (six-rowed) and the White Smyrna (two-rowed) being the earliest and the Princess the latest in ripening. The weight per bushel varied from 41 pounds for the Primus and Princess to 48 for White Smyrna. Only two varieties attained the legal weight, 48 pounds, in 1909.

The results obtained in the variety trials of barley at the Bellefourche Experiment Farm in 1908 and 1909 are given in Table XII.

TABLE XII.—*Annual and average yields and weight per bushel of 9 varieties of barley at the Bellefourche Experiment Farm, 1908 and 1909.*

G. I. No.	Name of variety.	Group.	Yield per acre (bushels).			Pounds per bushel.
			1908.	1909.	Average.	
643	Manchuria	Six-row	26.0	17.3	21.7	47.3
....	Manchuria (Minnesota No. 6)	...do	....	19.8	....	45.5
182	Odessa	...do	....	22.1	....	51.5
24	Hanna	Two-row	29.0	23.8	26.4	51.5
203	...do	...do	27.9	21.4	24.7	51.5
530	Chevalier	...do	....	22.1	....	51.0
531	Hannchen	...do	....	19.2	....	51.0
262	Hull-less	Hull-less	16.3	9.6	13.0	61.0
....	White Hull-less	...do	12.0	9.0	10.5	60.0

The highest average yield, 23.8 bushels, was obtained from a two-rowed variety, the Hanna. While trials for one or two years are insufficient to judge the relative value, the indications are that the two-rowed barleys are the most profitable in western South Dakota.

Kansas.

At the Kansas (Manhattan) station Tennessee Winter barley leads in yield, the average for six years being 48.80 bushels to the acre. Manchuria, the best six-rowed spring barley, gave an average yield of 33.53 bushels, which is 15.3 bushels less than that of Tennessee Winter for the same period. Table XIII shows the annual and average yields of 7 varieties grown at this station from 1904 to 1909.

TABLE XIII.—*Annual and average yields of 7 varieties of barley at the Kansas Station, 1904–1909.*[a]

Name of variety.	Yield per acre (bushels).						
	1904.	1905.	1906.	1907.	1908.	1909.	Average.
Manchuria	25.75	38.74	12.71	30.31	45.77	47.91	33.53
Manchuria (Mansury)	30.46	42.32	12.93	32.94	44.06	36.22	33.15
Common	26.92	46.55	16.39	14.83	42.89	26.71	29.05
Success Beardless	28.27	35.22	14.16	20.57	36.23	39.69	28.52
Black	19.89	32.75	14.40	21.08	37.03	31.50	26.11
Bonanza	27.43	42.89	12.56	29.23	44.96	35.53	32.10
Tennessee Winter	34.18	81.19	66.90	12.20	32.69	65.65	48.80

[a] From a special report made by Prof. A. M. Ten Eyck in 1909.

At the McPherson substation the 4-year average from 1906 to 1909 shows that the six-rowed spring barleys yielded best. Caucasian ranked first with an average of 30.3 bushels; Odessa and Yenidje followed with 28.9 and 28.5 bushels, respectively. The best yielding two-rowed barley was Black Smyrna, with a yield of 23.9 bushels. The winter barleys have not given as good results at this station as at Manhattan. They ranked lower than the two-rowed barleys.

TRIALS IN THE ROCKY MOUNTAIN AND PACIFIC STATES.

Montana.

Table XIV gives the average returns from the different groups of barley in a 2-year test at the Montana station.

TABLE XIV.—*Average yields of both grain and straw and average weight per bushel of the different groups of barley in a 2-year test at the Montana station.*

Group.	Number of varieties.	Average yield per acre.			Days to mature.	Pounds per bushel.
		Grain.[a]		Tons of straw.		
		Bushels.	Pounds.			
Hull-less	13	56.8	3,408	1.69	119	59.7
Two-row	13	66.0	3,168	2.00	119	50.5
Six-row	4	52.0	2,496	1.64	117	48.3

[a] The legal weight of hull-less barley is 60 pounds to the bushel, while that of the hulled type is 48 pounds. For this reason, the average yield in pounds of the hull-less varieties in this test was greater than that of the two-rowed hulled varieties though the hull-less produced the smaller number of bushels.

The following conclusions were drawn from the results presented in the foregoing table:

(1) The largest feed returns are obtained from the hull-less barleys.

(2) The two-rowed varieties gave much larger yields than the six-rowed.

(3) An average of the varieties tested shows a yield of 1.26 pounds of straw for each pound of grain in the two-rowed and 1.31 pounds of straw for each pound of grain in the six-rowed. In the hull-less barleys there was 1 pound of straw to each pound of grain.

The results ot only two years, 1909 and 1910, are available from the recently established Judith Basin substation at Philbrook, Mont. Table XV shows the yields obtained and the number of days required to mature. All except the hull-less varieties were sown at the rate of 4 pecks per acre; of these, only 3 pecks were sown.

TABLE XV.—*Average yields of 8 varieties of barley and the average time each required to mature in 1909 and 1910, also the weight per bushel of each in 1910, at the Judith Basin substation.*

Name of variety	Group.	Yield per acre (bushels).			Pounds per bushel. 1910.	Days to mature.
		1909	1910	Average.		
Hanna	Two-row	53.30	11.00	32.15	44	94.5
Bohemian	do	48.50	11.20	29.85	46	101.0
Mansury	do	45.70	13.00	29.35	....	94.5
Manchuria (Minnesota No. 105)	Six-row	45.20	9.80	27.50	44	98.5
White hull-less	Six-row hull-less	42.40	16.40	29.40	59	93.5
Black hull-less	do	43.80	13.60	28.70	58	95.0
Himalaya (Guy Mayle)	do	33.20	12.10	22.65	58	101.5
McEwan's hull-less	Two-row hull-less	32.60	10.00	21.30	58	95.0

The highest yield to the acre, 32.15 bushels, was obtained from a two-rowed variety, the Hanna; but the White Hull-less and the Black

Hull-less yielded only about 3 bushels less, and, owing to their greater weight per bushel, actually produced a greater number of pounds of grain than the Hanna.

Wyoming.

At the Laramie station the two-rowed barleys led in yield. In 1907 the 7 best two-rowed barleys averaged 35.6 bushels to the acre, and the 7 best six-rowed, 32.5 bushels. In 1909 the 3 best two-rowed varieties, Smyrna, Swan Neck, and Primus, averaged 43.3 bushels of 53 pounds in weight, while the best six-rowed, Gatami, Frankish, and Common Six-rowed, averaged 43.9 bushels of 49 pounds each. Two six-rowed hooded hull-less barleys averaged 31 bushels of 64 pounds each.

Colorado.

At the Akron substation in eastern Colorado the results of two years' experiments (1908 and 1909) in field plats show little difference in yield between the two-rowed and six-rowed barleys. California Feed, a six-rowed variety, led in yield, averaging 35.6 bushels, while Hannchen, the best two-rowed, averaged 34.8 bushels.

Utah.

At the Nephi, Utah, substation the six-rowed barleys have been most successful. The average yield of the California Prolific barley for the 7 years, 1904 to 1910, was 19.86 bushels, and of the Common California 19.69 bushels. The average yield of barley for two years, 1909 and 1910, was 17.85 bushels for Utah Winter and 17.30 bushels for Tennessee Winter. In these two years the spring barleys, California Prolific and Common California, averaged only about 7 bushels to the acre.

California.

Table XVI gives the average yields of barley grown on the experiment farm at Modesto, Cal., 1906 to 1909.

TABLE XVI.—*Average yields of 5 varieties of barley at Modesto, Cal., for periods varying from two to four years.*

Name of variety.	Group.	Years grown.	Yield per acre.
			Bushels.
Beldi	Six-row	2	22.75
Common	...do	3	26.70
Mariout	...do	3	15.15
Tennessee Winter	...do	2	25.65
White Smyrna	Two-row	4	24.54

The highest yields were obtained from Common California and Tennessee Winter, six-rowed varieties, and from White Smyrna, which is two-rowed. The yields were considerably reduced by the depredations of squirrels and by other detrimental factors. In 1908 White Smyrna yielded 65.02 bushels and Common, 55 bushels; in 1909 Tennessee Winter yielded 67.6 bushels. The average yield for the State is 26.5 bushels.

YIELD OF BARLEY COMPARED WITH THAT OF OTHER CEREALS.

Oats generally give a larger yield than barley in bushels per acre, but if the weight of grain produced is compared it will be found that barley generally gives the best returns. Table XVII shows that in the United States barley produces more pounds of grain to the acre than any of the other important cereals except corn.

TABLE XVII.—*Average yields of corn, barley, oats, wheat, and rye in the United States for each of four 10-year periods, 1866 to 1905.*

Period.	Average yield per acre (pounds).				
	Corn.	Barley.	Oats.	Wheat.	Rye.
1866–1875	1,461	1,099	899	714	594
1876–1885	1,438	1,075	833	738	473
1886–1895	1,310	1,084	819	762	390
1896–1905	1,411	1,204	947	810	452
Average	1,405	1,115	874	756	477

For the 10-year period from 1900 to 1909 barley gave an average yield of 25.7 bushels, or 1,234 pounds, of grain to the acre. The average yield of wheat was 10.8 bushels, or 648 pounds, per acre; of oats, 29.5 bushels, or 944 pounds; and of rye, 10.3 bushels, or 577 pounds. These figures show that barley produced nearly twice as much grain as wheat, 1.3 times as much as oats, and more than 2.1 times as much as rye. The average yield of corn of the 10-year period was 25.7 bushels, the same as barley; the weight of grain produced, however, was 1,439, or 205 pounds per acre more than barley.

The average yields in pounds per acre of the different grains for eight years at the North Dakota station were as follows: Oats, 1,969 pounds; emmer, 1,949 pounds; barley, 1,877 pounds; durum wheat, 1,835 pounds; common wheat, 1,711 pounds.

At Dickinson, N. Dak., in a 3-year test, from 1907 to 1909, of the comparative quantity of grain produced per acre by the different cereals, it was found that oats ranked highest, producing 2,311 pounds; barley came next, with 2,011 pounds; emmer third, with 1,893 pounds; and wheat fourth, with 1,871 pounds.

Interesting statistics covering a period of 26 years have been collected in Ontario, giving the average yields in bushels and pounds per acre of the grain crops grown in that Province. These figures are as follows:

Barley, 27.7 bushels; or 1,330 pounds per acre.
Winter wheat, 20.6 bushels; or 1,236 pounds per acre.
Oats, 35.8 bushels; or 1,217 pounds per acre.
Spring wheat, 15.9 bushels; or 954 pounds per acre.
Rye, 16.3 bushels; or 913 pounds per acre.

The standard weight per bushel of oats in Canada is 34 pounds, and of barley 48 pounds, consequently a bushel of barley weighs nearly as much as 1½ bushels of oats. While oats averaged 8.1 bushels more per acre than barley, on account of the greater weight per bushel the barley produced 113 pounds more grain. Barley produced a greater weight of grain per acre than any other cereal.

SOWING BARLEY AND OATS TOGETHER FOR GRAIN.

A common practice in some sections in Canada and of the United States is to sow barley and oats together for the production of grain, as increased yields are usually obtained. This mixed grain is, of course, not readily marketable, but is used for feeding on the farm where it is produced. Where barley and oats are sown together it is necessary to select varieties that mature about the same time.

As a result of two years' experiments in testing 19 different grain mixtures at the Ontario Agricultural College, the largest yield per acre of grain, 3,021 pounds, was produced from a mixture of 48 pounds of Manchuria barley and 34 pounds of Alaska oats. The next highest yield, 2,985 pounds, was from a mixture of 48 pounds of Manchuria barley and 34 pounds of Daubeney oats. Nearly always more than half of the crop produced was barley. In a mixture of 1 bushel each by measure of Manchuria barley and Banner oats sown together it was found that the crop was about two-thirds barley and one-third oats in weight. A mixture of 48 pounds of Manchuria barley and 60 pounds of Himalaya (Guy Mayle, hull-less) barley gave a yield of 2,986 pounds.

The same institution has conducted experiments for a number of years with various mixtures of oats and barley in order to find the rate of seeding which would give the best results. The lightest seeding was one-half bushel of each and the heaviest 1½ bushels of each by weight. The trial was continued for six years, 1899 to 1904, the average results showing that the greatest number of pounds of grain per acre was produced from a mixture of 1 bushel of oats (34 pounds) and 1 bushel of barley (48 pounds), or 82 pounds of the mixture to the acre. In 1907 a test was conducted along the same line, using Manchuria six-rowed barley with Daubeney oats and Chevalier two-rowed barley with Siberian oats. In 1908 Canadian two-rowed barley was used instead of Chevalier. Nine different combinations of oats and barley were used, varying from 3 to 5 pecks of each grain. The highest average yield of grain for the two years, 2,566 pounds, was produced from the seeding of 4 pecks each of oats and barley, a close second being 2,537 pounds from 3 pecks of oats and 5 pecks of barley. Four pecks of oats and 5 pecks of barley produced 2,529 pounds of mixed grain. The largest average quantity of straw, 1.70 tons, for the two years was from the 4 pecks of oats and 3 pecks of barley, the smallest being 1.55 tons from 5 pecks of oats and 4 pecks of barley.

DISEASES AFFECTING BARLEY.

Barley is subject to a number of diseases, of which the most injurious are the rusts and smuts. Brief descriptions of these diseases, with methods of treatment, follow.

Loose smut of barley (*Ustilago nuda*) is a fungous parasite that infects the plant at the flowering time of the grain. The following year the plants grown from seeds matured from infected flowers produce smutted heads. Within a short time after the maturity of the spores they are scattered by the wind and only the bare stem remains. Figure 17, *B*, shows heads of barley affected with loose smut. The disease is widely prevalent, in some localities the loss incurred being from 2 to 10 per cent of the crop. The disease can be controlled by treating the seed with the modified hot-water treatment in connection with a seed plat.[a]

Covered smut of barley (*Ustilago hordei*) infects the plant in a different manner. The spore does not enter the seed, but simply adheres to it and is sown with it, infecting the young plant just after the germination of the seed. While the barley is maturing each grain is replaced by a mass of dark spores. The spores are then scattered over the grain in harvesting and thrashing. Machinery, sacks, and bins which contain smut spores are frequent sources of infection. Figure 17, *A*, shows heads of barley in which the grains are replaced by masses of spores of this smut. Treating the seed for 30 minutes with a solution of 1 pound of formalin[b] to 40 gallons of water will aid in preventing it.

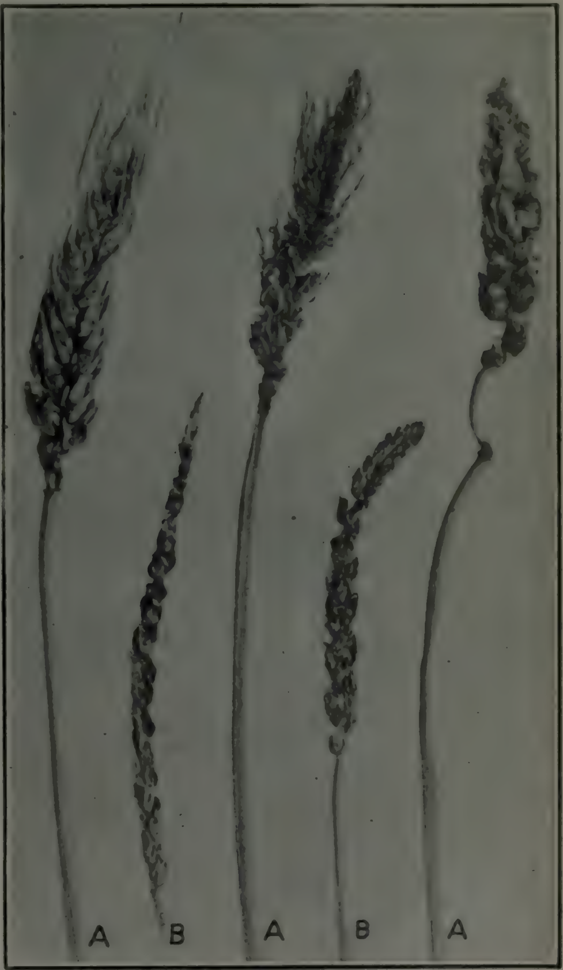

FIG. 17.—The covered and loose smuts of barley: *A*, Covered smut, in which the kernel is replaced by masses of spores; in the left-hand head the awns are reduced in size; in the center head the spikelets are distorted and the awns nearly destroyed; the right-hand figure is that of a head of hooded barley, showing the large spore masses. These are broken apart and mixed with the grain in thrashing. *B*, Loose smut. In this form the entire spikelet is replaced by a mass of spores, which upon maturity are scattered by the wind, leaving only the bare stems as evidence of the disease.

Barley is subject to both leaf rust (*Puccinia simplex*) and stem rust (*Puccinia graminis hordei*). The first stage of these diseases is called the "red-rust stage" and may be recognized by the reddish-brown spots on the stems and leaves. The spores formed in these spots are scattered by the wind and cause infection the same season. Cool, dewy nights and muggy days are especially favorable to the development of the rust. Later in the season black elongated spots can be seen on the stems and bases of the leaves. These contain the spores which will live over winter. No absolute remedy is known. Burning the straw and stubble of badly infected fields has been recommended as a preventive against rust the following season. As squirrel-tail grass, quack-grass, and slender wheat-grass are subject to rust, they should not be allowed to grow in or near grain fields. The selection of early-maturing and rust-resistant varieties of barley and the use of well-drained land are recommended.

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[a] A detailed description of the hot-water method of treatment for loose smut of barley is given in Bulletin 152, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1909.

[b] A more complete description of the formalin and other treatments for covered smut of barley is given in Farmers' Bulletin 250.

Ergot (*Claviceps purpurea*) is not common on barley, but is occasionally found in the Great Plains States. It is due to a parasite which attacks the immature grains and replaces them by large black or purplish-black masses. These fall off and remain in the field over winter, or are sown with the grain, and from them come the spore-producing bodies in which are formed the spores which attack the crop. No absolute preventive is known. It is desirable to separate the black masses from the grain by screening before planting.

Yellow-leaf disease of barley (*Helminthosporium graminum*), while not common in all parts of the United States, has caused considerable damage in certain portions. Dr. L. H. Pammel described it as one of the most destructive of the parasitic diseases affecting barley in Iowa. Attacks have also been noted in the Southern and Central States. The disease may be identified by the yellowing and splitting of the leaves of the young plant. Frequently the entire plant is affected and may be killed by the fungus. A close inspection of the diseased leaves will show small black spots which contain the spores. No remedy is known.

Powdery mildew (*Erysiphe graminis*) sometimes occurs on this crop, but it is generally not severe enough to cause much damage. It is easily recognized by the small, cottony masses (mycelium) on the leaves. This disease receives its nourishment by sending its sucker-like organs, known as "haustoria," into the outer cells of the leaf, causing them to turn brown. It is spread by means of spores, which generally attack the basal leaves of the plant first and are most injurious in thickly sown grain on damp ground. Well-drained fields suffer least.

INSECTS INJURIOUS TO BARLEY.

Insects affecting the growing crop.—Barley, like other grain crops, is attacked by a number of injurious insects. Among those which attack the growing crop is the spring grain-aphis,[a] or "green bug" (*Toxoptera graminum*). During the season of 1907 many acres of barley in Kansas, Oklahoma, and Texas were ruined by it.

The Hessian fly[b] (*Mayetiola destructor*) is so well known that no description is necessary. While by preference it attacks wheat, it will also breed in barley, especially in localities where the barley is planted earlier than the wheat.

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[a] A full description of the spring grain-aphis, with suggestions for its control, is given in Circular 93, Bureau of Entomology, U. S. Dept. of Agriculture.

[b] Methods of prevention and treatment for the Hessian fly are given in Circular 70, Bureau of Entomology, U. S. Dept. of Agriculture.

In some localities the chinch bug[a] (*Blissus leucopterus*) infests barley and causes considerable damage.

Insects attacking the stored grain.—Among the injurious insects which attack stored grain are the Angoumois grain moth and the various grain beetles and weevils. The presence of the Angoumois grain moth can be noted as the adults fly around the seed room or bin when the grain is disturbed. The moth resembles the common clothes moth. The larva burrows into and consumes the interior of the grain, leaving only the outer portion. A poor stand of grain is very often due to the fact that the germs were destroyed by the larvæ of this insect. The grain weevils and the small, elongated, reddish-brown or blackish beetles, which differ from the weevils in not having the elongated snout, also damage stored grain, especially in the South. Fumigation with carbon bisulphid or hydrocyanic-acid gas is effective in keeping all these insects in check; but fumigation should not be undertaken without a thorough knowledge of the methods of using these chemicals, for both are dangerous to handle.[b]

Seed grain can be protected from both insects and vermin by storing it in galvanized-iron bins with tight lids, or in tight wooden bins inclosed with small-mesh wire netting. Before the grain is placed in the bin it should be fumigated with carbon bisulphid. The fumes should not be inhaled, and, as they are highly inflammable, no light should be brought near while the chemical is being used.

IMPROVEMENT OF THE CROP.

STATEMENT OF METHODS.

The mean yield of barley in the United States for ten years, 1900 to 1909, was 25.7 bushels to the acre. The lowest annual average yield for that period was 20.4 bushels, in 1900; and the highest, 29 bushels, in 1902. Many methods of improving the yield and quality of the crop are practiced, but the most important are (1) the introduction of improved seed from other countries, (2) the improvement of the varieties now grown, (3) the production of new strains by hybridization, (4) the proper selection and preparation of the soil, and (5) the use of the best methods in harvesting.

THE INTRODUCTION AND DISTRIBUTION OF PURE SEED.

Practically all the pure races of barley now grown in the United States have been produced by the experiment stations or introduced by the Department of Agriculture. These pure strains have proved their superiority wherever the conditions have been favorable. The Offices of Seed and Plant Introduction and of Grain Investigations of this Department are giving much attention to the improvement of barley, the former through the introduction of new varieties, the latter by testing a large number of varieties, the selection of those best adapted to the different areas, and the production of pure strains.

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[a] The chinch bug is discussed in Circular 113, Bureau of Entomology, U. S. Dept. of Agriculture.

[b] Full directions for fumigation with hydrocyanic-acid gas are given in Circular 112, Bureau of Entomology, U. S. Dept. of Agriculture, and for fumigation with carbon bisulphid in Farmers' Bulletin 145.

The most promising of the introduced varieties are the Chevalier, Hannchen, Hanna, Primus, Swan Neck, Princess, Odessa, and Gatami. Several excellent strains of winter barley have been developed. The variety known as Tennessee Winter, which was selected at the Tennessee station, has been widely distributed by the Department of Agriculture over the Southern and South-Central States with excellent results. In many localities it has entirely replaced the spring barleys. Several forms of winter barley without awns have been produced by the Office of Grain Investigations, which will no doubt prove of considerable value when fully developed.

THE IMPROVEMENT OF EXISTING VARIETIES.

Means of selection.—The varieties of barley which are now commonly in cultivation in the United States can be improved (1) by the mechanical selection of the seed and (2) by the field selection of the best plants or heads.

Mechanical selection.—The seed is a vital factor in the production of good barley, for it contains the germ and the food material to start either a strong and vigorous plant or a weak and puny one. If the seed is small and shriveled maximum yields can not be expected. It is for this reason that the farmer is urgently advised to fan and clean his seed in order to remove the weak and save only the plump grain. Experiments have shown that these imperfectly formed seeds seldom produce plants with large, well-developed heads, and that these plants stool less than those produced from large, plump seeds. By thoroughly fanning and screening the seed and further cleaning it by the skimming process later described, the imperfect barley grains, oat and weed seeds can be removed and only the plump barley saved. By planting only the plump grain the stand and yield will be greatly improved.

An excellent method by which light and diseased grains of barley and impurities such as oats and weed seeds can be removed, and by which the grain can be treated for smut at the same time, is as follows:[a] Make a formalin solution at the rate of 1 pound of formalin to 40 gallons of water; partly fill a tub with this solution and pour into it the seed to be treated. Stir the seed thoroughly and skim off the oats, weed seeds, and chaffy grains which rise to the surface. The solution should then be drained off and the seed dried in a clean place.

Field selection.—The barley crop can be further improved by the selection of the best plants in the field. In all fields of grain individual plants can be found that are superior to the rest, either in height or form of plant, or size of head or grain. These better individuals should be selected and planted separately the following season, thus establishing pure types of the variety. The best selections should then be increased until they can be put into field tests.

Results may be obtained more quickly by selecting a large number of the best heads of the same type and planting them together, though the chances of mixture are considerably greater and the variety will not be as pure as when only one head is used. By sowing the grain produced by the selected heads the following year in a separate plat, for convenience called the "breeding plat," the grower can readily see whether they come true to type. If the weak and undesirable plants and those that do not come true to type are removed, the yield and quality of the variety can be considerably improved within a few years.

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[a] A complete description of this method of cleaning seed barley is given in Circular 62, Bureau of Plant Industry, U. S. Dept. of Agriculture.

At the Kansas station Mansury, Bonanza, and Manchuria barleys have been selected for 3 years, 1907 to 1909, and the average yields increased from 0.62 bushel to 4.75 bushels during that time. At the Wisconsin, Minnesota, Tennessee, and many other stations excellent results have been obtained and the varieties much improved by careful selection of the seed.

SUMMARY.

Barley is supposed to be a native of western Asia, where wild forms still exist. It was one of the first cereals cultivated for food. Barley belongs to the grass family or Gramineæ, and to the genus Hordeum.

There are two groups of barley, the two-rowed and the six-rowed. Further subdivisions are made into bearded and hooded (beardless) types, including both the common and the hull-less varieties in each type.

This crop was introduced into America by the early colonists. Improved varieties were first distributed in the United States about 1845. Among the most important introductions were the hooded types, including hull-less forms. In recent years a number of valuable varieties have been introduced by the Department of Agriculture from Europe.

The greater portion of the crop is produced in the States of Minnesota, California, Wisconsin, North Dakota, and South Dakota.

The six-rowed barley is most widely grown in the United States. The best yielding varieties are Manchuria, Oderbrucker, Odessa, Gatami, and California. Among the best of the two-rowed varieties may be mentioned Chevalier, Hannchen, Swan Neck, Kitzing, and Hanna. The hooded (beardless) and hull-less barleys yield well in the semiarid and Rocky Mountain States. In the Southern and Central States the winter varieties are the most profitable ones to grow.

Barley requires a well-drained, porous soil for its best development. Loamy soils give the best yields.

Barnyard and green manures should be plowed under for some time previous to planting this crop. If fertilizers are used, they should be rich in phosphates.

Barley should follow corn, potatoes, or other cultivated crops in the rotation. It is an excellent nurse crop for legumes and grasses.

In preparing the soil for barley it should be well worked and free from weeds.

All light seed and impurities should be removed by fanning and screening or by the skimming process.

In the Northern States barley is sown from April 1 to May 15, while in the Central States seeding is generally done from March 15 to April 15. In the Pacific States this crop is sown either in the winter or spring. Winter barley in the Southern States is usually sown from September 15 to October 15. The usual rate of seeding in humid regions is 2 bushels; where the rainfall is slight, best results are obtained from the use of 4 to 6 pecks. Drilling gives better results than broadcast seeding.

In the semiarid regions harrowing after the plants come up is often beneficial. Considerable barley is grown under irrigation in the Intermountain States.

To obtain the best quality of grain, barley should be cut when in the hard-dough stage. Some growers prefer to cut when fully ripe. The grain should be shocked in oblong rather than in round shocks, as the oblong shocks allow it to cure better. Where there are no high winds, the shocks should be capped. The grain is of much better color and quality if the crop is stacked instead of being allowed to stand in the shock till thrashing time. In thrashing barley the concaves should not be set too close, or there will be considerable broken grain. The grain should be carefully housed after thrashing to prevent injury from moisture and insects.

Barley is subject to both loose and covered smut. Loose smut can be controlled by the modified hot-water treatment, while treating the seed with formalin will destroy the covered smut.

The growing grain is sometimes injured by the " green bug," chinch bug, and Hessian fly. Rotation of crops, and, for the Hessian fly, rotation with reasonably late seeding, are the most efficient remedies. Insects which attack barley in the bin can be kept in check by fumigating with hydrocyanic-acid gas or carbon bisulphid.

Numerous tests of varieties of barley have been made at the various State agricultural experiment stations. Oderbrucker, a six-rowed variety, produced the highest yield at the Wisconsin station. At the Minnesota station Manchuria and Russian were the best six-rowed varieties; Hannchen, Chevalier, and Primus are the best two-rowed. At the North Dakota station Russian was the best six-rowed barley and Moravian the best two-rowed. At the Edgeley and Dickinson substations the two-rowed varieties led in yield, while at Williston the six-rowed were best. The best six-rowed barley yielded slightly more than the best two-rowed at the South Dakota station. At the Highmore substation and the Bellefourche Experiment Farm the two-rowed varieties yielded best. At Manhattan, Kans., Tennessee Winter barley led in yield and Manchuria was the best spring variety. At McPherson, Kans., the six-rowed spring varieties yielded best. At the Montana station the largest feed returns were obtained from the hull-less varieties. The two-rowed barleys were superior to the six-rowed at the Wyoming station. At Akron, Colo., and Modesto, Cal., these two groups differed little in yield. At Nephi, Utah, the six-rowed barleys are the most profitable.

In order to prevent its running out or deteriorating, the seed grain should be thoroughly cleaned and graded before planting. This will insure strong, healthy plants and a good quality of grain. Where no fanning mill is available, the skimming process gives excellent results.

A small breeding plat, in which is planted the seed from selected heads gathered from the standing grain, will enable the farmer to improve the yield and quality of his crop.

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Issued April 21, 1911.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 444.

REMEDIES AND PREVENTIVES AGAINST MOSQUITOES.

BY

L. O. HOWARD, PH. D.,
Entomologist and Chief, Bureau of Entomology.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., March 1, 1911.

Sir: I have the honor to transmit herewith a manuscript on "Remedies and Preventives against Mosquitoes," which is largely a condensation of the most important of the matter contained in Bulletin No. 88 of the Bureau of Entomology. The bulletin in question contains a very extended consideration of the subject, including long quotations and a discussion of the value of remedies of secondary or even less importance, upon which, nevertheless, an expression of the judgment of the Bureau was thought desirable. I recommend the publication of this paper as a Farmers' Bulletin.

Respectfully,

L. O. Howard,
Entomologist and Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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REMEDIES AND PREVENTIVES AGAINST MOSQUITOES.

INTRODUCTION.

Since the discovery that mosquitoes are not only nuisances, but are also conveyers of malaria, yellow fever, filariasis, and dengue fever, a great deal of remedial work has been done by individuals and communities. Many remedies and plans of action have been tested on a large scale, and what follows is a summary of the results.

PROTECTION FROM BITES.

PROTECTIVE LIQUIDS.

Spirits of camphor rubbed upon the face and hands or a few drops on the pillow at night will keep mosquitoes away for a time, and this is also a well-known property of oil of pennyroyal. Neither of these substances is durable; that is to say, a single application will not last through the night. Oil of peppermint, lemon juice, and vinegar have all been recommended, while oil of tar has been used in regions where mosquitoes are especially abundant. Oil of citronella is one of the best substances to be used in this way. The odor is objectionable to some people, but not to many, and it is efficient in keeping away mosquitoes for several hours. The best mixture tried by the writer was sent to him by Mr. C. A. Nash, of New York, and is as follows:

Oil of citronella	1 ounce
Spirits of camphor	1 ounce
Oil of cedar	½ ounce

Ordinarily a few drops on a bath towel hung over the head of the bed will keep the common house mosquitoes away. Where they are very abundant and persistent a few drops rubbed on the face and hands will suffice. Even this mixture, however, loses its efficacy toward the close of a long night. It is the habit of the yellow-fever mosquito, *Aëdes* (*Stegomyia*) *calopus* Meig., to begin to bite at daylight. By that time the average person is sleeping very soundly, and the effects of the mixture will usually have largely passed away. It follows that in the Southern States where this mosquito occurs these protective mixtures are not supposed to be as effective as they are in the North. As a matter of fact, however, this last mixture, could it be applied shortly before dawn, would be as effective as under other circumstances.

A mixture recommended by Mr. E. H. Gane, of New York, is as follows:

Castor oil	1 ounce
Alcohol	1 ounce
Oil of lavender	1 ounce

This mixture was prepared for the purpose of avoiding the odor of the oil of citronella.

Oscar Samostz, of Austin, Tex., recommends the following formula:

Oil of citronella	1 ounce
Liquid vaseline	4 ounces

This mixture greatly retards the evaporation of the oil of citronella. Mr. B. A. Reynolds has used successfully in New Orleans 20 minims of oil of citronella to the ounce of vaseline or lanolin.

A 5 per cent solution of sulphate of potash has been recommended, as also the oil of cassia. Pure kerosene has also been used extensively in the Philippines.

SCREENS AND CANOPIES.

Such obvious measures as the screening of houses, the use of netting for beds, and the wearing of veils and gloves after nightfall in badly infested regions need no detailed consideration. Screening of houses can not be too carefully done, and adjustable, folding, or sliding window and door screens seem never to be tight; even with well-fitted screens there are often opportunities for mosquitoes to enter; constant care and vigilance alone will prevent this. In certain seasons in mosquito regions mosquitoes will attempt to make their way through screens and are often able to do so. When they are very numerous wire screens should be painted lightly with kerosene or oil of citronella.

With bed canopies there should be ample material to admit of a perfect folding of the canopy under the mattress, and the greatest care should be taken to keep the fabric well mended. It often happens in mosquito regions that little care is taken of the bed nettings in the poorer hotels, and it is necessary for perfect protection that a traveler in the Southern States should carry with him a pocket "housewife" and should carefully examine his bed netting every night, prepared to mend all tears and expanded meshes. Veils and nettings for camping in the Tropics or other regions where mosquitoes abound are absolutely necessary. Light frames are made to fit helmetlike over the head and are covered with mosquito netting. Similar frames, readily folded into a compact form, are made to form a bed covering at night, and every camping outfit for work in tropical or malarial regions should possess such framework and plenty of mosquito netting as an essential part of the outfit.

The size of the mesh in mosquito bars and window screens is important. Twenty meshes to the inch can be relied upon to keep mosquitoes out, but 15 to the inch admits some of them.

SCREENING BREEDING PLACES.

Where the rain-water supply is conserved in large tanks, as in cities in the Gulf States, screening is necessary and is now rather generally enforced. Rain-water barrels everywhere should be screened in the same way, except where fish are used to kill the early stages of mosquitoes. A cheap cover for a water barrel can be made by covering a large iron hoop with a piece of stout calico or sacking, free from holes, in such a manner that a good deal of sag is left in the material.

SMUDGES AND FUMIGANTS.

Anything that will make a dense smoke will drive away mosquitoes, and various smudges are used by campers. For household use a number of different substances have been tried.

PYRETHRUM POWDERS.

Pyrethrum powders, known to the trade as Dalmatian insect powder, Persian insect powder, buhach, and otherwise, are very effective when fresh and pure. Pure powders are the finely ground flower-heads of two species of composite plants of the genus *Pyrethrum.* The essential principle seems to be a volatile oil that disappears with age and exposure. Many powders for sale in the drug stores are apparently diluted by the grinding of stems as well as flower-heads and in other ways. These powders are not so effective as pure powders. Pyrethrum powders are usually used dry, and are puffed or blown into crevices frequented by insects, or puffed or blown into the air of a room in which there are mosquitoes. The burning of the powder in a room at night is common practice. The powder is heaped up in a little pyramid which is lighted at the top and burns slowly, giving out a dense and pungent smoke. Often the powder is moistened and molded roughly into small cones, and after drying it burns readily and perhaps with less waste than does the dry powder. Mosquitoes are stupefied by the smoke and fall to the floor, where they may be swept up and burned. With open windows and constant currents of fresh air this fumigation is not especially effective, and it is necessary, for protection, to sit in a cloud of smoke.

The powder may be placed upon a metal screen above the chimney of a kerosene lamp, with the result that the vapor of the volatile oil will be dissipated. This is said to be very effective. It is economical in powder, and the odor is slight. Another method of burning the powder is to puff it from an insufflator into a burning gas jet. In New Orleans it has been found that in order to thoroughly clear houses of mosquitoes pyrethrum must be burned at the rate of nearly 1 pound of powder to every 1,000 cubic feet of space.

MIMMS CULICIDE.

This mixture is made of equal parts by weight of carbolic acid crystals and gum camphor. The acid crystals are melted over a gentle heat and poured slowly over the gum, resulting in the absorption of the camphor and a final clear, somewhat volatile liquid with an agreeable odor. This liquid is permanent, and may be kept for some time in tight jars. Volatilize 3 ounces of this mixture over a lamp of some kind for every 1,000 cubic feet of space. A simple apparatus for doing this may be made from a section of stovepipe cut so as to have three legs and an outlet for draft, an alcohol lamp beneath and a flat-bottom basin on top. The substance is inflammable, but the vapor is not explosive. The vapor is not dangerous to human life except when very dense, but it produces a headache if too freely breathed. Rooms to be fumigated should be made as nearly air-tight as possible.

SULPHUR DIOXID.

Burning of sulphur, or lump sulphur, in a small pot, at the rate of 2 pounds of sulphur for each 1,000 cubic feet of space, is efficient against mosquitoes where fumigation in the case of possible disease-bearing mosquitoes is desired.

OTHER FUMIGANTS.

According to Dr. John B. Smith, powdered jimson weed (*Datura stramonium*) can be burned to advantage in houses. He recommends 8 ounces to fumigate 1,000 cubic feet of space. He states that it should be made up by the druggist into an amount with niter or saltpeter 1 part to 3 of Datura, so as to burn more freely. He states that the fumes are not poisonous to human beings, are not injurious to fabrics or to metals, and can be used with entire safety. He suggests that it be burned in a tin pan or on a shovel.

The burning of dried orange peel has been recommended as a deterrent against mosquitoes by a Japanese physician.

APPARATUS FOR CATCHING ADULT MOSQUITOES.

An interesting homemade apparatus in common use in many parts of the United States is very convenient and effective. It consists of a tin cup or a tin-can cover nailed to the end of a long stick in such a way that a spoonful or so of kerosene can be placed in the cup, which may then, by means of the stick, be pressed up to the ceiling so as to inclose one mosquito after another. When covered over in this way the captured mosquito will attempt to fly and be caught in the kerosene. By this method perhaps the majority of the mosquitoes in a given bedroom—certainly all of those resting on the ceiling—can be caught before one goes to bed.

Mr. H. Maxwell-Lefroy, of India, makes a trap consisting of a wooden box lined with dark-green baize and having a hinged door. The trap is 12 inches long, 12 inches broad, and 9 inches deep. A small hole, covered by a revolving piece of wood or metal, was prepared in the top of the box. Owing to the habit of mosquitoes to seek a cool, shady place in which to rest, such as a dark corner of the room or a book shelf, or something of that sort, they will enter the trap, which is put in the part of the room most frequented by mosquitoes, all other dark places being rendered uninhabitable so far as possible. They are driven out of book shelves with a duster or with tobacco smoke, and go into the desirable sleeping place for the day. The door is then closed and fastened, and into the small hole at the top of the box a teaspoonful or less of benzine is introduced. This kills all of the mosquitoes inside, and the box is then thoroughly aired and replaced. In this way Mr. Lefroy is very successful in catching mosquitoes. At one time he averaged 83 a day.

REMEDIES FOR MOSQUITO BITES.

The most satisfactory remedy known to the writer, from his personal experience, has been moist soap. Wet the end of a piece of ordinary toilet soap and rub it gently on the puncture, and the irritation will soon pass away. Others have enthusiastically recommended household ammonia, or alcohol, or glycerin. One correspondent marks the puncture with a lump of indigo; another with one of the naphthaline moth balls; another, iodin. Rev. R. W. Anderson, of Wando, S. C., states that he has found that by holding his hand to a hot lamp chimney the irritation of mosquito punctures will be relieved instantly.

ABOLITION OF BREEDING PLACES.

It has been found that, taking the group of mosquitoes as a whole, their breeding places are of the most diverse character. Some species, however, are restricted in the character of their breeding places.

Certain forms, for example, breed only in tree holes; others in accumulations of water in epiphytic plants; another species breeds only in the crabholes on sea beaches. Others are of more general breeding habits and will live in almost any chance accumulation of water. Certain species breed only in the salt marshes and may lay their eggs on mud, and most others lay their eggs upon the surface of water. Certain of the species, especially those occurring inland, in the more northern States, seem to breed only in the pools formed by melting snow, and as these occur at only one time of the year there is but one generation, and the eggs are laid in midsummer or later in such hollows in the earth as will be filled by the melting snow the ensuing spring. Another species, which is frequently very annoying in certain of the northern States, breeds only in the stems of certain aquatic plants. Still another breeds in the pitchers of pitcher plants (Sarracenia).

Culex pipiens L. in the North and *Culex quinquefasciatus* Say and *Aëdes* (*Stegomyia*) *calopus* Meig. in the South, however, breed in every chance receptacle of water about residences, and their destruction means the abolition or treatment of all such receptacles.

Where the rain-water barrel and rain-water tank are necessary they should be screened. About a given house the waste places in the immediate vicinity should be carefully searched for tin cans, bottles, and wooden or tin boxes in which water can accumulate and all such receptacles should be destroyed or carried away. The roof gutters of every building should be carefully examined to make sure that they are not clogged so as to allow the water to accumulate. Where the branches of tall trees overhang roofs this is especially likely to occur by the agency of falling leaves or twigs. The chicken pans in the poultry yard, the water in the troughs for domestic animals, the water cup of the grindstone are all places in which these mosquitoes will breed and water should not be allowed to stand in them for more than a day or so at a time.

In the South the water accumulating under water tanks should be treated or drained away. The urns in the cemeteries in New Orleans have been found to breed mosquitoes abundantly. The holy-water fonts in churches, especially in the South, have been found to breed mosquitoes abundantly. In slightly marshy ground a favorite breeding place is the footprints of cattle and horses. In one country village, which contained many small vegetable gardens in clay soil, during a rainy season mosquitoes were found breeding abundantly in the water accumulating in the furrows in the gardens.

Even in the house these mosquitoes breed in many places where they may be overlooked. Where the water in flower vases is not frequently changed mosquitoes will breed. They will breed in water pitchers in unused guest rooms. They will breed in the tanks in the water-closets when these are not frequently in use. They will breed in pipes and under stationary washstands where these are not frequently in use, and they will issue from the sewer traps in back yards of city houses during dry spells in the summer time when the sewers have not recently been flushed by heavy rains. In warehouses and on docks they breed abundantly in the fire buckets and in water barrels. Of course such places as these can not be abolished, but should be treated in accordance with measures indicated in another section of this bulletin.

In country houses in the South, where ants are troublesome, and where it is the custom to insulate the legs of tables with small cups of water, mosquitoes will breed in these cups unless a small quantity of kerosene is poured in. Where broken bottles are placed upon a stone wall, water accumulates in the bottle fragments after rains, and mosquitoes will breed there.

Old, disused wells in gardens are frequent sources of mosquito supply, even where apparently carefully covered, and here the nuisance is easily abated by the occasional application of kerosene. The same thing may be said of cesspools. Cesspools are frequently covered with stone and cement, but the slightest break in the cement, the slightest crack, will allow the entrance of these minute insects, and unlimited breeding often goes on in these pools without a suspicion of the cause of the abundance of mosquitoes in the neighborhood.

Fountains and ornamental ponds are frequent breeding places, and here the introduction of fish, as indicated in another place, is usually all-sufficient. It frequently happens, however, that the grass is allowed to grow down into the edges of ornamental ponds and mosquito larvæ find refuge among the vegetation and so escape the fish. Broad-leaved water plants are also often grown in such ponds, and where these broad leaves lie flat on the surface of the water, as they frequently do, one portion of a given leaf may be submerged so that mosquito larvæ may breed freely in the water above the submerged portion of the leaf, protected from the fish by the leaf itself, the fish rising from below. It is necessary, therefore, to keep the edges of such ornamental ponds free from vegetation, and to choose aquatic plants whose growth will not permit of mosquito-larvæ protection.

In these latter localities not only the house mosquitoes, previously mentioned, or the rain-water barrel mosquitoes will be found, but also some of the other forms, and particularly the malaria-breeding mosquitoes of the genus Anopheles. Some of these breed in all sorts of water accumulations.

In many small country towns, even where there is a water supply, tanks are to be found under the roofs to supply bathrooms. Such tanks should be screened, since mosquitoes gain entrance to the tank room, either through dormer windows or by flying up through the house from below, in search of places to lay their eggs.

About a large old house or a public building there are so many of these chance breeding places that only the most careful and long-continued search will find them all. As an example, in a State hospital, after a search which lasted for many days, and after a treatment of all possible breeding places found, mosquitoes still continued to annoy the patients. Finally in the darkest part of a disused cellar was found a half-barrel with standing water in it, which was giving out mosquitoes at the rate of hundreds per day. Frequent change of water or the use of kerosene will render all such breeding places harmless.

In community work in cities all of the points mentioned must be borne in mind, and in the portions of the community where the residences are for the most part villas, in the absence of swampy suburbs the householders are in the main responsible for their own mosquitoes. There are, however, breeding places for which the municipality may be said to be responsible, and these entirely aside from public fountains, reservoirs, or marshes. Roadside open gutters or ditches may breed a generation of any one of several species of mosquitoes, including malarial mosquitoes. On a pasture or common, where sod has been removed, water accumulating in the excavation thus formed may breed a generation of malarial mosquitoes. All such accidental breeding places should be abolished by filling in.

It seems unlikely that in any general sewage system mosquitoes may breed in the sewers proper. That they do breed in the catch basins is well known. The purpose of the catch basin is to catch and retain by sedimentation sand and refuse which would otherwise enter the sewer and deposit in it. It is intended to be water tight and to hold a considerable body of water, which stands in it up to the level of the outlet pipe. Such catch basins are very commonly used in back yards and at the crossings of streets. The water is removed only by rain or when the street or yard surfaces are washed. In dry seasons the period of stagnation may last several weeks, certainly long enough for mosquito breeding. As a matter of fact mosquitoes in midsummer do breed in such traps or catch basins by millions. These basins may be treated with petroleum, or the municipal authorities may flush them once a week, carrying away such larvæ as may have hatched. Kerosene treatment, however, is best.

Public dumps are great breeding places, because here accumulate old bottles, cans, boxes, bits of tin or iron vessels, and other objects in which water may accumulate for a time. Even a very small amount of water will make a breeding place for very many mosquitoes. It is quite possible for a half of a beer bottle to contain enough water to give out literally thousands of mosquitoes. The writer knows of one instance where a veritable plague of mosquitoes was traced to a case of empty beer bottles allowed to remain in a back yard for some weeks in midsummer.

There is a possibility that under certain circumstances mosquitoes may breed in water accumulating in the troughs of underground-conduit electric railways. There is abundant opportunity for water to accumulate in these troughs, but no exact observations upon mosquito breeding in such situations have been made.

Search carefully for all such places, and either abolish the standing water by carting away chance receptacles, by turning over vessels, by filling in excavations, or by treating other receptacles with a film of kerosene, or by introducing fish into fountains and artificial pools.

DRAINAGE MEASURES.

Drainage measures really form a part of the consideration of the treatment of breeding places. The drainage of swamp areas for agricultural or industrial reasons needs no argument. The value of reclaimed swamp land for various purposes is well known. The drainage of swamp areas primarily in order to improve sanitary conditions and to reduce the scourge of mosquitoes which in itself often prevents the proper development of nearby regions is in operation and needs no argument. Drainage on a small scale for the purpose of doing away with mosquitoes has been practiced for a long time, and in many parts of the country large-scale drainage with mosquito abolition in view is going on, notably in New Jersey and in California. Methods of draining can not be entered into in this bulletin, but it should be pointed out that in case of salt-marsh land the operation is inexpensive, and results of great value have been reached both in California and in New Jersey.

DESTRUCTION OF LARVÆ BY TREATMENT OF BREEDING PLACES.

While it is obviously best to abolish breeding places in the ways mentioned, it often happens that it is not possible to drain, and at least as a temporary expedient it becomes desirable to treat the water so as to kill the mosquito larvæ. Many substances have been tried, and, aside from certain proprietary mixtures, nothing has given such good results as the use of oils. Efforts to find oils that can be used to better advantage than petroleum have failed. Common kerosene of low grade, or of the grade known as fuel oil, is the most satisfactory as regards efficiency and price.

In choosing the grade of oil two factors are to be considered: First, it should spread rapidly; second, it should not evaporate too quickly. The heavier grades of oil will not spread readily over the surface of the water, but will cling together in spots and the coating will be unnecessarily thick. The rapidity of spread of the film is also important. As to quantity, under still conditions, an ounce of kerosene to 15 square feet of surface space is about the right proportion, and in the absence of wind such a film will remain persistent for 10 days or slightly longer. Even after the iridescent scum apparently disappears there is still an odor of kerosene about the water. In a wind the film of kerosene is frequently blown to one side, but with a change will go back again, so that larvæ are destroyed. Not only are larvæ and pupæ destroyed by the kerosene film, but many adult mosquitoes alighting on the surface of the water to drink or to lay their eggs are killed by it. In California, Mr. H. J. Quayle has used a combination of heavy oil of 18° gravity and a light oil of 34° gravity, in the proportion of 4 to 1, respectively. This mixture made an oil that was just thin enough to spray well from an ordinary spray nozzle and yet was thick enough to withstand very rapid evaporation. It was applied by a barrel pump where this could be used, and by an ordinary knapsack pump in other regions. A single application was found by Mr. Quayle to be effective sometimes up to four weeks. The army of occupation in Cuba used oil every two weeks.

The use of a spray pump has been mentioned. Small ponds can be sprinkled out of an ordinary watering pot with a rose nozzle, or for that matter pouring it out of a dipper or cup will be satisfactory. In larger ponds pumps with a straight nozzle may be used. A straight stream will sink and then rise and spread until the whole surface of the pond can be covered without waste. The English workers in Africa advise mopping the kerosene upon the surface of the water by means of cloths tied to the end of a long stick and saturated with kerosene.

In Panama a larvicide is being used which is made as follows: 150 gallons of carbolic acid is heated in a tank to a temperature of 212° F., then 150 pounds of powdered or finely broken resin is poured in. The mixture is kept at a temperature of 212° F. Thirty pounds of caustic soda is then added and the solution is kept at the same temperature until a perfectly dark emulsion without sediment is formed. The mixture is thoroughly stirred from the time the resin is used until the end. One part of this emulsion to 10,000 parts of water is said to kill Anopheles larvæ in less than half an hour, while 1 part to 5,000 parts of water will kill them in from 5 to 10 minutes. At a larvicide plant at Ancon 4,600 gallons of this mixture were made at a cost of $0.1416 per gallon. Although this mixture has been used to a large extent in Panama, crude oil was also used for streams having a fair velocity.

THE PRACTICAL USE OF NATURAL ENEMIES OF MOSQUITOES.

The common goldfish and silverfish destroy mosquito larvæ and should be put in artificial ponds. Top-minnows of several species have been introduced successfully in several localities and are great feeders upon mosquito larvæ. Certain species introduced from Texas into Hawaii have been successful; and a small top-minnow of the genus Girardinus, known in the Barbados as "millions," has been carried with success to others of the British West India Islands. In Rio de Janeiro another top-minnow has been used by the public health service for placing in tanks and boxes where it was impossible to use petroleum.

There are many predatory aquatic insects that feed upon mosquito larvæ; others that catch the adults. Certain birds prey upon the adults, and they are also eaten by bats. An experiment is being carried on near San Antonio, Tex., in which a bat roost has been constructed with the dual purpose of gathering the bats to kill mosquitoes of that region and of collecting the bat guano.

DETERRENT TREES AND PLANTS.

A great deal has been published concerning the properties of certain growing plants which are said to keep away mosquitoes. Among these may be mentioned several species of Eucalyptus, the castor-oil plant, the Chinaberry tree, and others. Although the evidence in regard to these plants is contradictory, all observations made by scientific men in different parts of the world negative their value; claims that they are valuable are confined to people who have not made thoroughly scientific tests.

[A list showing the titles of all Farmers' Bulletins available for distribution will be sent free upon application to a Member of Congress or to the Secretary of Agriculture.]

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Issued April 17, 1911.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 445.

MARKETING EGGS THROUGH THE CREAMERY.

BY

ROB R. SLOCUM,
Animal Husbandman in Poultry Investigations,
Animal Husbandry Division, Bureau of Animal Industry.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Animal Industry,
Washington, D. C., February 17, 1911.

Sir: I have the honor to transmit herewith a paper on "Marketing eggs through the creamery," by Mr. Rob R. Slocum, of the Animal Husbandry Division of this Bureau. This paper, which was included in the Twenty-sixth Annual Report of the Bureau, presents a plan for marketing eggs while they are fresh, avoiding the heavy losses which occur under the common methods, and resulting to the advantage of both producer and consumer. I respectfully recommend that it be issued in the Farmers' Bulletin series.

Respectfully,

A. D. Melvin,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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MARKETING EGGS THROUGH THE CREAMERY.

During the fall and winter months it is the current opinion among consumers of eggs, when they are compelled to pay high prices for such occasional dozens of strictly fresh eggs as they are able to procure, that the farmer or the poultryman, the original producer, is receiving a high price for his product as it leaves his hands. This is true in the main in so far as the producer is concerned who is so situated that he can either retail his eggs directly or place them in the hands of a dealer or retailer who can dispose of them within a short time while they are still fresh. In so far as the general farmers, who produce the great bulk of eggs, are concerned, this is not the case. The price received by the general farmers of the Middle West, of most of the South, and of many other localities, while varying with the season, is, during a considerable portion of the year, often much below and apparently out of proportion to the prices paid by the consumer.

The reasons for this lie in the lack of care given the eggs and in the methods of handling used in connection with the present system of marketing, and not, as a rule, in the realization of an undue or unreasonable profit by the egg handlers or dealers.

THE USUAL METHOD OF MARKETING EGGS.

At the present time the common method of marketing eggs in the Middle West is in brief as follows: The farmer gathers his eggs whenever convenient, sometimes each day, sometimes two or three times a week. The eggs are brought to the house and kept until there is a sufficient number to take to the village or until the farmer makes a trip to the village for some other purpose and takes the eggs along. No particular attention is given to the conditions under which the eggs are kept in the meantime. They may be put in a pantry or cupboard of the kitchen where the temperature is comparatively high and where the eggs are bound to undergo considerable deterioration in quality or to reach a more or less advanced stage of actual spoiling. Even in those cases where the importance of a low temperature may be realized and an effort made to secure this by placing the eggs in a cellar, there is likelihood that the cellar may be damp, and the eggs in consequence become moldy. Likewise no particular effort is made to obtain clean eggs by proper attention to the nests and by frequent gathering or to separate the clean from the soiled eggs when taking them to market. Whenever a nest of eggs is discovered in the weeds or about the barn they are usually added to the eggs in the market basket without question as to whether they are partly incubated.

As a result the farmer starts for town with a basket of eggs, part of which are perfectly fresh and wholesome, part of them dirty or smeared, and part of them shrunken or stale or even partly or wholly spoiled. These eggs the farmer takes to the village store and receives for them a certain price per dozen, which is usually given in trade. The village merchant is not a dealer in eggs from choice, but rather because he feels it necessary to take the eggs in order to keep the trade of the farmer. If he does not take the eggs he fears that the farmer will offer them to one of his competitors and will in consequence be likely to give that competitor the bulk of his trade. For the same reason the merchant believes that he must accept the eggs as they run, good or bad, fresh or stale, clean or dirty, for if he does not his competitors will.

The merchant holds the eggs until he has enough to make a shipment to some egg dealer or shipper from whom he gets regular quotations. The delay here may be anywhere from two days to a week, or even two weeks. Usually the conditions attendant upon the shipment of these eggs up to the time they reach the packing house are such as to cause a still further deterioration in the eggs. After they reach the packing house they are assembled in great enough numbers so that more attention and care is given their handling, and although the eggs go through one or more sets of hands from this point before they are placed in storage or reach the consumer, the deterioration which they undergo is usually not so great proportionately.

For more detailed information regarding the complex process of marketing eggs the reader is referred to Circular 140 of the Bureau of Animal Industry.

The result of this common and almost universal method of marketing eggs is that when the eggs leave the hands of the country merchant, and still more when they reach the packer, quite a large proportion, varying with the season and the weather, are either seriously deteriorated or are wholly bad. It is usual somewhere during the process of marketing, after the eggs have left the hands of the country merchant, for them to undergo a grading process, in the course of which the bad eggs are discarded and the deteriorated eggs are separated and eventually sold for a less price than they would bring were they of first quality. Obviously, the man who buys these eggs "case count," candles them, and sells the graded product must protect himself from loss as a result of the eggs thrown out, and this he does by paying a lower price per dozen for the eggs he buys than he would were the eggs all good or reasonably good. As a result this lower quotation must be passed back to the storekeeper and eventually to the farmer.

The average farmer through carelessness and lack of knowledge produces indifferent eggs; the method of buying in vogue places no premium on quality, and the farmer producing clean eggs and putting them in the hands of the storekeeper in a good, fresh condition realizes no more for them than does the careless farmer, one-quarter or one-third of whose eggs may be bad. The subsequent course of the eggs to the market and to the table of the consumer usually includes a grading process for the purpose of culling out the bad and deteriorated eggs, and this in turn makes necessary a reduction in the price which can be paid to the producer.

To correct this injustice to the careful farmer and to place a premium on the production of good eggs and their subsequent careful handling, a system of buying is necessary which bases payment on quality. It is not the purpose of the writer to enter into a discussion of the general problem of "loss-off" buying in its relation to the commercial egg, but simply to describe a system of marketing which is in successful operation and which seems to be accomplishing this result.

HOW EGGS ARE MARKETED THROUGH A MINNESOTA CREAMERY.

The marketing of eggs in this particular instance is accomplished through a creamery in the northern part of Minnesota. Because of the fact that farmers must take their milk or cream to the creamery at frequent and regular intervals, it is an agency especially well suited to obtaining the egg in a fresh condition from the farmer. As it seems that there must be other creameries so situated that they could readily put their eggs directly in the hands of a retailer in a fair-sized city with only a short shipment, it seems well to describe in detail the methods used in this case. The volume of eggs handled in this way would, of course, probably never become so great as to make them a factor in the mass of eggs now handled commercially.

As stated before, the eggs are brought by the farmer directly to the creamery when bringing his milk. While this particular creamery is privately owned, it is essentially cooperative, in that its owner and manager is a far-sighted business man with other interests in the village, and he sees that the increased agricultural prosperity of the community will eventually be to his advantage. In consequence he is content to take a small profit for himself and to pay the farmers as liberally as possible for both their cream and eggs. Any patron of the creamery or any other person who will sign a required agreement may market his eggs in this way. At present about one hundred and thirty-five farmers are taking advantage of this method of disposing of their eggs. These egg patrons are scattered over quite a wide territory, one man finding it to his advantage to drive in 14 miles with his eggs.

The agreement reads as follows:

> For the privilege of selling eggs to the creamery company and getting a market established for guaranteed fresh eggs, I, the undersigned, hereby pledge myself to comply in every way with the following rules:
>
> I agree to deliver eggs at the creamery that will not be to exceed 8 days old and to be picked in (gathered) twice every day.
>
> Eggs to be of uniform size (no under size or over size eggs).
>
> Eggs to be clean and to be kept in a cool, dry cellar.
>
> Brown eggs to be put in one carton and white in another and so marked.
>
> Each egg to be stamped on the side and carton to be stamped on the top.
>
> I agree not to sell any eggs that I have marked with the creamery company's trade-mark to anyone else but the creamery company, and to return stamps and other supplies that have been furnished, in case I should decide to discontinue to sell eggs to the creamery company.

It is readily discernible from the provisions of this agreement that the aim is to get a grade of uniform, clean, dependable eggs, of reasonable freshness. It might seem that requiring delivery once in eight days would not be frequent enough, but the nights in Minnesota even in summer are said to be usually cool, and this condition, together with the gathering twice a day and the storage in dry, cool cellars, must account for the fact that no complaints have been received on the score of staleness.

The separation of the brown and the white eggs serves two purposes. First, it promotes uniformity and greater attractiveness of appearance, and second, it encourages the keeping of the breeds of hens which lay white eggs, because the owner of the creamery pays during the spring months 1 cent more for white eggs than for brown. The creamery owner justified this action by the statement that it was his belief that his markets would pay a premium for white eggs in the near future, and that he wished to stimulate the keeping of one class of chickens, so as to insure a more uniform product.

To every person signing the agreement quoted above a small rubber stamp is given for use in stamping the eggs and the container. This stamp plays an important part in the system of marketing. It contains the name of the creamery, the creamery brand, and a serial number for each producer. By means of the stamp which thus appears on each egg and on each package it is possible to trace the product back to the individual producer, and in consequence to place the blame for any carelessness or poor quality where it belongs. A repetition of any offense of this nature may be sufficient ground for refusing to handle the eggs of that particular producer.

When the creamery patron signs the agreement, and at such times thereafter as may be necessary, he is furnished with a supply of cartons or containers in addition to the rubber stamp. These cartons are the ordinary one-dozen size pasteboard egg boxes which are so shaped that they may be packed in a regular 30-dozen egg case. The following guaranty is printed on the top of the carton:

This package contains

ONE DOZEN GUARANTEED FRESH EGGS

——— Creamery Company,

Manufacturers and Dealers

EGGS, BUTTER, PASTEURIZED CREAM, AND ICE CREAM

——— Minnesota.

NOTE.—Eggs in this package, if they have our trade-mark on them, are guaranteed to be strictly fresh, clean and full size, and if ever found otherwise, we wish you would do us the favor to report it, giving number found on the egg.

——— Creamery Company.

The farmer takes these cartons home, and as the eggs are gathered each day, the clean, good-sized eggs are stamped and placed in them. When a carton is filled it is stamped on its upper side just the same as the eggs.

When the farmer comes in to the creamery with his milk or cream he brings along as many cartons or dozens of eggs as he has. The man in charge of the creamery takes these eggs, examines the packages, and gives the farmer a check for the eggs delivered that day. The cartons are then packed in substantial returnable 30-dozen egg cases and shipped to market by express. The shipping charges are paid by the consignee. The labor and cost of handling the eggs at the creamery are thus reduced to a minimum. The eggs are never candled, reliance being placed on the farmer to bring in good eggs. The cost of handling the eggs, including the cost of the carton, which is about one-half cent, is estimated to be 1 cent a dozen. The farmer in turn feels bound to be particular, knowing that any carelessness can be traced back to him and realizing that he thus jeopardizes his chances of continuing to dispose of his eggs in this manner. This he can not well afford to do, as will be shown later by a comparison of the prices received for eggs marketed through the creamery and through the general store.

In this particular case the creamery happens to be located within easy shipping distance of Duluth, Minn., and this city was chosen as a market for the eggs. One of the best grocery stores was already handling butter made by the creamery and was in consequence glad to take the eggs. The eggs, therefore, pass through only one dealer between the creamery and the consumer. These eggs, because fresh, were soon in great demand by the customers of this store, and though sold for several cents a dozen more than other eggs handled, were always taken in preference. It is interesting to note that during the year and a half that this store has been handling the eggs, only two complaints have been made as to their quality. It is also significant of the recognition of their quality that the demand for them has greatly increased and that persons living on the opposite side of the city make special trips to this store by street car solely for the purpose of buying some of these eggs. The brand which is placed on the eggs and on the cartons has become strongly associated with quality in the minds of the consumers. This is illustrated by the statement of the storekeeper that two cases of these eggs which came in unbranded for some reason or other were disposed of as eggs from this particular creamery only after a good deal of difficulty and on the personal guaranty of the proprietor. The consumers noticed the absence of the brands and demanded eggs so stamped.

ADVANTAGES OF THE SYSTEM.

Previous to the inauguration of this method of handling the eggs by the creamery the farmers brought their eggs to the general store and traded them for merchandise in the usual manner. When the creamery first began to handle eggs this innovation was looked upon with disfavor by the merchants, who feared that they would lose some trade because of the fact that the farmers received cash for their product. Gradually, however, these merchants have come to realize that as this method brought a greater return to the community for its eggs, it helped to increase the general prosperity and that under these circumstances their trade improved rather than degenerated. In consequence they have come to favor the step heartily, to feel a pride in it, and finally to feel grateful for being relieved of the necessity of handling the eggs.

The advantage of this system of marketing, to the farmers or producers, has come about in two ways: First, it has increased the price paid to them by compelling an improvement in quality, by selling more directly to the consumer, and by establishing a reputation for the eggs sold under the creamery brand. Second, it has brought about the realization that poultry raising by the general farmer is profitable, that the income from this source is considerable, and that it is capable of increase by keeping better fowls and giving them better care.

The increase in price which the farmer is realizing for his eggs as a consequence of the introduction of the new method varies with the season. During the spring, when eggs are plentiful and quite uniformly good in quality, the difference is small and does not amount to over 1 or 2 cents. From this time on the difference increases until the following winter, when it reaches as high as 10 cents or more. During the month of December, 1909, when this creamery was visited, farmers were receiving 40 cents a dozen for their eggs and continued to do so during the entire month. At this very time, as determined by personal investigation, farmers in a village of a near-by portion of the State were receiving 25 cents a dozen. There was, moreover, absolutely no expense of marketing to come out of this 40 cents, as even the cartons in which the eggs were packed were furnished by the creamery. From the following table giving the average price paid by the creamery by months during 1909 it can be seen that the return to the farmer is very satisfactory, and far better than that received where eggs are marketed through the country store, where a bad egg is worth, or rather brings, as much as a good egg:

Average price paid by creamery for eggs in 1909.

Month.	Number marketed.	Average price paid farmer.
	Dozens.	*Cents.*
January	630	35.6
February	1,329	25.9
March	1,771	19.0
April	2,069	18.2
May	2,445	19.8
June	1,725	20.0
July	1,509	22.7
August	1,898	24.5
September	1,562	25.1
October	507	27.0
November	229	37.4
December	810	40.0

In this particular Minnesota village during the year 1907, which was just previous to marketing the eggs by the new method, the eggs received by the storekeepers hardly more than supplied the local demand. In fact, during the whole of that year only 15 cases, or 450 dozen eggs, were shipped out of the village. During the year 1909 nearly $4,000 was paid out by the creamery for eggs, all of which were shipped away. The impetus which has been given the poultry business during the short time this method of marketing has been practiced may be judged from the statement of the proprietor of the creamery that from present indications he expected the egg business to double or treble during the year 1910.

Along with this increase in the volume of egg receipts, which indicates a realization of the profitableness of the business and an increase in the number of fowls kept, has come an awakening to the value of better stock and improved methods. It is noticeable that purebred poultry is being introduced and is replacing the old flocks of mongrel fowls. Poultry papers are being subscribed for and publications on poultry raising are in demand. New and better hen houses are being built and systematic attention is being given to the care and feeding of the fowls. The great part of this awakening to the possibilities of poultry keeping is directly traceable to the method of marketing the eggs through the creamery which is used in this locality.

SIMILAR SYSTEMS IN OTHER LOCALITIES.

In at least one other locality in Minnesota a very similar system of egg marketing is in operation. In this village, however, a little settlement of Danes, the eggs are not marketed through a creamery, but through an association formed solely for the purpose of marketing eggs. The details of the process are practically identical, and it is planned to handle the eggs through a cooperative creamery which the settlers expect to start in the near future. At present the secretary of the association attends to the business of marketing the eggs without compensation.

In still another locality which boasts a strong cooperative creamery it is the intention to begin handling eggs on exactly the same plan, except probably to require somewhat more frequent delivery of eggs during the hot summer months. Still another locality intends to accomplish the same end by means of a man paid to handle the eggs and attend to the marketing. In this case, too, the details of the collection and delivery of the eggs by the farmers will be almost identical with the method described above, except that the eggs will not go through the creamery.

CONCLUSION.

It can not be denied that in the particular case described above, marketing eggs through the creamery has been a success. It has brought about carefulness on the part of the producer and a most decided improvement in the quality of the eggs. It has, moreover, provided the market with a grade of good, fresh eggs, which are always in good demand and which at present are almost unobtainable at certain seasons in the cities. It has, in doing this, prevented a considerable waste and loss in quality which is normally associated with the marketing of eggs in the Middle West, and has increased very materially the price which the producer receives. It would appear, in view of the fact that the creamery seems a logical and natural agency for the handling of eggs to good advantage, that this method, with modifications, is adaptable to a wide range of conditions, and that many creameries could well afford to make eggs as well as butter one of the products which they handle. Wherever this method is adopted it should mean a most acceptable increase in the price received by the farmer for his eggs, and this without any increase in cost to the consumer.

FARMERS' BULLETINS.

Bulletins in this list will be sent free, so long as the supply lasts, to any resident of the United States, on application to his **Senator, Representative, or Delegate in Congress**, or to the Secretary of Agriculture, Washington, D. C. *Because of the limited supply, applicants are urged to select only a few numbers, choosing those which are of special interest to them.* Residents of foreign countries should apply to the Superintendent of Documents, Government Printing Office, Washington, D. C., who has these bulletins for sale. Price 5 cents each to Canada, Cuba, and Mexico; 6 cents to other foreign countries. The bulletins entitled "**Experiment Station Work**" give briefly the results of experiments performed by the State experiment stations.

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28. Weeds: And How to Kill Them.
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32. Silos and Silage.
34. Meats: Composition and Cooking.
35. Potato Culture.
36. Cotton Seed and Its Products.
44. Commercial Fertilizers.
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437. A System of Tenant Farming and Its Results.

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Issued May 8, 1911.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 446.

THE CHOICE OF CROPS FOR ALKALI LAND.

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WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., March 8, 1911.

Sir: I have the honor to transmit herewith and to recommend for publication as a Farmers' Bulletin a manuscript entitled "The Choice of Crops for Alkali Land," prepared by Mr. Thomas H. Kearney, Physiologist in Charge of Alkali and Drought Resistant Plant Breeding Investigations.

The information here presented is based largely upon experimental work, much of which was carried on in cooperation with the Nebraska Agricultural Experiment Station at the North Platte substation.

Respectfully,

Wm. A. Taylor,
Acting Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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THE CHOICE OF CROPS FOR ALKALI LAND.

PURPOSE OF THE BULLETIN.

One of the most serious obstacles to agriculture in the arid portion of the United States is the frequent presence in the soil of alkali—an excess of readily soluble salts. Irrigated land that has a high water table is most likely to suffer from this cause.

The history of agricultural development in the West contains numerous instances of irrigation projects that had a promising beginning in localities where land values have subsequently been much impaired by the rise of alkali. It has been estimated that one-tenth of the irrigated land in the western United States, or approximately 850,000 acres, contains an injurious quantity of alkali salts. Some of the most valuable land in that part of the country, adapted at the outset to the best-paying crops and situated most advantageously with respect to towns and transportation lines, has become practically useless through the operation of this cause.

The remedy unquestionably is to get rid of the excess of salts wherever possible by flooding and drainage. But it often happens that there are obstacles in the way of reclaiming alkali land. The individual farmer may not be able to secure an outlet for his waste water until a cooperative drainage system has been established in his neighborhood. Climatic conditions or the distance from markets may prevent the growing of sufficiently profitable crops to warrant the cost of reclamation. Even where reclamation is feasible the process often requires several years, and meantime both the land and the farmer's pocketbook will benefit if some crop is put in at the earliest stage when a stand can be secured. Prolonged flooding without cropping is apt to impair the texture of the soil, especially if a heavy one, causing it to become puddled. This will be avoided to some extent if crops are grown during the progress of reclamation.

The object of this bulletin is to bring to the attention of owners of alkali land the crop plants which are most likely to give satisfactory results. It can not be too emphatically stated that crop

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production on such soils is at best precarious. For this reason and because the alkali resistance of plants depends upon many varying conditions, it is impossible to offer more than suggestions as to what crops are best worth trying.[1]

CHEMICAL NATURE OF ALKALI.

Alkali consists of various chemical compounds (salts) which are often present in western soils in sufficient quantity to hinder or prevent the growth of plants. Most of these salts are familiar to everyone from their medicinal or household uses. The most common of these substances are Glauber's salt (sodium sulphate), table salt (sodium chlorid), and baking soda (sodium bicarbonate). The so-called "black alkali" is sal soda, or washing soda (sodium carbonate). Epsom salts (magnesium sulphate) is also an important ingredient of alkali in certain localities. All of these salts readily dissolve in water. Less soluble compounds that often occur in alkali soils are the carbonates of lime and magnesia and the sulphate of lime (gypsum, or land plaster).

It seldom, if ever, happens that only one kind of salt is present. Alkali is almost always a mixture of several salts, the kinds and the proportions in which they are mixed differing in different localities. But often some one salt forms the bulk of the alkali, and hence we can speak of "sulphate alkali" where Glauber's salt and other sulphates are the chief ingredients, of "chlorid alkali" where common salt is the most abundant, and of "black alkali" where a considerable quantity of sodium carbonate occurs.

In many irrigated districts, especially in those situated east of the Rocky Mountains, Glauber's salt (sodium sulphate) forms the bulk of the alkali. But in some of the largest areas of alkali land in the United States common salt (sodium chlorid) is the most abundant compound present. Considerable quantities of sodium bicarbonate are often associated with both the sulphate and the chlorid types. The areas where black alkali (sodium carbonate) predominates are much more restricted.

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[1] The scope of this paper does not include methods of reclamation for alkali land. Problems of soil management are discussed only incidentally in connection with the different crops. For information upon these subjects and upon the chemistry and physics of alkali, the reader is referred to other publications of the Department of Agriculture and of the State agricultural experiment stations, notably those by Prof. E. W. Hilgard and his associates of the California Experiment Station. In Bulletin 35 of the Bureau of Soils, entitled "Alkali Soils of the United States," by Mr. Clarence W. Dorsey, brief summaries are given of the most important previous publications, in addition to a general discussion by the author. In Professor Hilgard's work on "Soils," published in 1906, the subject of alkali soils is treated at considerable length (pp. 422–484). Methods for the reclamation of alkali land by drainage are described in Farmers' Bulletin 371, entitled "Drainage of Irrigated Lands," by Charles F. Brown; and in Bulletin 217, Office of Experiment Stations, entitled "Drainage of Irrigated Lands in the San Joaquin Valley, California," by Samuel Fortier and Victor M. Cone.

REASONS FOR THE APPEARANCE OF ALKALI.

The characteristic alkali salts are readily soluble in water and when dissolved move upward or downward as the soil moisture moves. Conditions that favor evaporation from the surface of the soil favor the accumulation of alkali at or near the surface, while a rainfall or an irrigation drives the salts downward. Alkali is rarely found in the United States east of the ninety-fifth meridian, not because eastern soils are essentially different from western soils, but because the heavier rainfall of that part of the country leaches out most of the soluble matter as fast as it is formed in the soil and carries it away in the country drainage. In many parts of the Western States the rainfall is too scanty to effect this leaching and the salts remain in the soil, often at or near the surface.

In land that has never been irrigated, the presence of alkali is seldom apparent except in low spots where water accumulates during rains and in valley bottoms where the ground water table is close to the surface. Yet after irrigation has begun alkali often appears at the surface of land which previously seemed to be quite free from it. In such case the salts may have been present originally in lower depths of the soil, and it is the raising of the water table resulting from continued irrigation which has brought them into connection with the moisture of the upper layers. Evaporation will then gradually lift the alkali to the surface and if long continued will cause the formation of the characteristic white crust of salts. Or it may be the application of water to adjoining higher lands which has filled the lower-lying areas with an excess of salts, the surplus water having drained off into the valley bottoms and carried there with it a great part of the salts originally contained in the upland soils from which it came. Continued irrigation with river or well water having a high salt content is another cause of land becoming impaired through the accumulation of alkali.

In districts where alkali soils occur, the fields are apt to have a spotted appearance, due to the accumulation of the salts in more or less sharply defined areas, outside of which there may not be a sufficient quantity of alkali to interfere with the growth of crops. The bare spots may be only a few feet in diameter, or they may occupy several acres. This local accumulation of the alkali is usually due to differences in level, the salts accompanying the water to the low spots. Differences in soil texture also play a part, the water and the dissolved salts accumulating where the soil is least pervious and the drainage is poorest.

EFFECT OF ALKALI UPON PLANT GROWTH.

The harmfulness of alkali depends not only upon the quantity and the kind of salts, but also upon the amount of moisture the soil contains. The soil moisture is controlled by climatic conditions (rainfall, evaporation, etc.), by the frequency and heaviness of irrigation, by the texture of the soil, and by the conditions for drainage. Furthermore, the distribution of the salts in different depths of the soil, in relation to the character of the root system of the plant, must be taken into consideration.

COMPARATIVE HARMFULNESS OF DIFFERENT KINDS OF ALKALI.

The sulphates, chlorids, and bicarbonates, collectively known as "white alkali," are much more abundant in most localities than the carbonates, or "black alkali."

Black alkali, which can usually be recognized by the dark color it imparts to the surface soil and to standing water,[1] is far more injurious to plants than the white-alkali salts. It is a strong corrosive, causing the decay of plant tissues. Trees growing in black-alkali land are sometimes completely girdled at the crown through the corrosive action of the sodium carbonate. This salt also has a bad effect upon the texture of heavy soils, causing them to become puddled.

Where the soil contains considerable black alkali it is useless to attempt to grow crops until this condition is remedied. If gypsum, or land plaster, can be obtained at a reasonable cost, and the value of the land warrants its use, the black alkali can often be converted to less harmful salts by successive applications of this fertilizer. The effect of the gypsum is to neutralize chemically the black alkali. This results in loosening the soil, making it easier for water to penetrate, and aiding the washing down of the other salts. The presence of more than one-tenth of 1 per cent of sodium carbonate is injurious to the growth of practically all crop plants. For most species one-twentieth of 1 per cent (0.05 per cent) of this extremely noxious salt is too much for good crop production.

The white-alkali salts are not corrosive, but when freely taken up into the cells of the plant they cause serious disturbances in its nutrition. If present in the soil in sufficient quantity, these salts also hinder the absorption of water by the plant roots, so that even when the soil is quite wet the plants may actually be suffering from lack of water. This is doubtless one of the chief reasons why seeds germinate more slowly where alkali is present.

The chlorid type of white alkali is somewhat more harmful to most crop plants than the sulphate type. The bicarbonates as such do not appear to be very injurious, but there is always danger where bicarbonates are present that black alkali will be formed by chemical action.

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[1] This indication is sometimes misleading, however, for the dark color may be produced by less harmful salts, and the carbonates themselves may not produce the stain if the soil contains but little humus.

QUANTITY OF ALKALI PRESENT.

The harmfulness of alkali depends upon the quantity as well as the kind of salts present. The alkali content of a soil is usually expressed in percentages of its total dry weight. Thus, if 100 pounds of dry soil contains 1 pound of salts that are easily soluble in water, its alkali content is said to be 1 per cent. As a rule, if the soil contains more than one-half of 1 per cent of white-alkali salts, only decidedly resistant plants can be grown.

The kind of salts present in a given alkali soil can be determined only by chemical analysis, but if there is not enough black alkali to turn red litmus paper blue when brought in contact with the wet soil it will usually suffice for practical purposes to ascertain merely the total quantity of easily soluble material. This is most readily done by determining the electrical resistance of the soil when saturated with water. A convenient instrument for this purpose is the electrical bridge, described in Bulletin 61, Bureau of Soils, United States Department of Agriculture (1910). From the electrical resistance the percentage of salts to dry weight of the soil can be calculated.

SOIL MOISTURE.

Salts can affect plant growth only when they are dissolved in water. Hence, even if the total quantity of alkali in a given volume of soil remains the same, the strength of the solution which surrounds the roots and from which they must extract the water and plant-food salts needed for growth will vary with every change in the soil moisture. For example, if 20 pounds of water be added to 100 pounds of air-dry soil containing 1 pound of alkali salts, the bulk of the salts will be dissolved in the 20 pounds of water and the concentration of the soil solution will be approximately 1 part in 20, or 5 per cent. If an additional 20 pounds of water is added without increasing the quantity of salts present, the concentration of the soil solution will be reduced to 2.5 per cent. If the soil is now allowed to dry out until it contains only 10 pounds of water, a 10 per cent solution will result, supposing the moisture and the salts dissolved in it to remain evenly distributed throughout the soil.

It is therefore evident that a mere statement of the percentage of alkali present in a soil tells us little about how plants will be affected. It is the strength of the solution around their roots which concerns them. Plants which could make a thrifty growth in a soil containing a given percentage of alkali, provided that irrigation were so managed as to maintain a moisture content of 30 per cent, might suffer severely if the same soil, without change in the alkali content, were allowed to dry out until only 20 per cent of moisture remained.

Similarly, some plants which can endure 1 per cent of alkali if present in a heavy soil would quickly perish in a sandy soil containing the same quantity and the same kind of salts, the reason being that the heavier soil can hold more water. If a clay loam and a very sandy soil both hold 1 per cent by dry weight of alkali and are both saturated with water, the soil solution in the former may be only one-fourth as concentrated as in the latter.

The moisture content of the soil is, of course, subject to the control of climatic factors, especially precipitation and evaporation. In regions of winter rainfall like California a winter crop might succeed better in alkali land of a given concentration than a summer crop that is actually more resistant. During the rainy season the soil solution is frequently diluted by the water that falls upon the land, and evaporation is relatively slight. Hence, the surface soil is likely to remain nearly free from salts during the entire period when the crop is growing. On the other hand, the growth of the summer crop takes place during the period when evaporation is most rapid and is tending to accumulate the salts near the surface of the soil. At the same time the dry, hot weather stimulates transpiration or loss of water from the plants themselves just when the increased concentration of the soil solution makes it hardest for their roots to take up water. An irrigated summer crop is subject to great fluctuations in this respect, the soil solution being very dilute immediately after an application of water, but becoming daily more concentrated through the action of evaporation.

Methods of irrigation have a great deal to do with the movement of the soil moisture and consequently with the distribution of the alkali. If the land is level, a heavy flooding will cause the water to move downward over the whole surface of the field, carrying the salts with it. On the other hand, furrow irrigation drives down whatever alkali is present at the bottoms of the furrows, but subirrigates the soil between them, causing an accumulation of salts at the summits of the ridges. This action will be intensified if the irrigation water itself carries considerable alkali.

STAGE OF GROWTH OF THE PLANT AND CHARACTER OF ITS ROOT SYSTEM.

Another important consideration in determining the effect of a given quantity of alkali is its vertical position in the soil in relation to the depth reached by the plant roots. A comparatively small quantity of alkali, if mostly accumulated near the surface, will prevent getting a stand of many crops which can be successfully started if a heavy rain or irrigation has occurred just before planting is done. The effect of the large quantity of water thus added is, of course, to drive much of the salt into the lower depths of the soil, leaving a comparatively dilute solution in the portion occupied by the germinating seeds and the roots of the young seedlings. Then by the time evaporation has produced a new accumulation of salts at the surface, the feeding roots of the plants may have penetrated deep enough to be out of reach of the concentrated solution that has once more formed in the topsoil. Alfalfa serves to illustrate this relation, since the seedlings develop a taproot that penetrates very rapidly into the soil. If the salts have been washed out of the surface 6 inches just previous to seeding, a stand may be obtained and the plants may escape injury, even if an alkali crust is subsequently formed. This doubtless explains the fact that flourishing fields of alfalfa several years old are occasionally seen where the quantity of salts now present in the topsoil would make it impossible to get a stand, the alkali having evidently risen since the seeding was done.

On the other hand, most of the alkali may be located in a deeper portion of the soil, a condition which is especially unfavorable to deep-rooted plants, such as alfalfa, cotton, and trees. In irrigated land this condition is nearly always associated with a high water table, which is itself unfavorable to deep-rooted plants, but deep-lying deposits of salts may occur in unirrigated soils or in irrigated soils having a low water table. Such deposits are often associated with a clay subsoil or a lime hardpan. In these cases comparatively shallow-rooted plants like the cereals and the meadow grasses can often be successfully grown where deep-rooted plants would soon die.

GERMINATION.

It is evident from the foregoing that on alkali land, no matter what crop is grown, it is always advisable to put in the seed as soon as possible after a heavy rainfall or irrigation. This is especially important with small seeds, like those of the meadow grasses and of alfalfa. If even with this precaution the topsoil still holds a fairly strong salt solution, there is good reason to believe that large-seeded plants can often be started more easily than small-seeded plants of the same family. The vigorous early growth that is permitted by a large seed stored with abundant reserve food materials and the resulting rapid penetration of the roots are probably the deciding factors in such cases.

NATURE OF THE PRODUCT FOR WHICH THE CROP IS GROWN.

Because a plant can grow in the presence of a given quantity and kind of alkali it does not necessarily follow that it will be a successful crop under such conditions. The effect upon the product for which the crop is grown must also be considered. Wheat plants can make a good growth in the presence of a quantity of alkali that will not permit the formation of well-filled heads of plump grain. Various kinds of fruit trees can endure a concentration of alkali that seriously injures the texture, sweetness, flavor, and keeping property of the fruit. The burning quality of tobacco, the length and fineness of cotton fiber, and the sugar content and purity coefficient of sugar cane and beets may be impaired by a quantity of salts that is too small to interfere seriously with the growth of the plants. On the other hand, in the case of such forage plants as are grown chiefly for a large production of stems and leaves, the actual alkali resistance of the plants as shown by their vegetative growth measures the possibility of crop production on alkali land.

CROP PLANTS ADAPTED TO DIFFERENT GRADES OF ALKALI.

GRADES OF ALKALI DISTINGUISHED.

The following grades of alkali may be distinguished, the grades being based upon the percentage of soluble salts by weight in a given depth of the soil. In referring to the different grades when discussing the alkali resistance of any particular crop plant, it is assumed that the depth of soil is that ordinarily occupied by the roots of the plant in question.

TABLE I.—*Classification of the different grades of alkali.*

Designation of the grade.[1]	Proportion of soluble salts to total dry weight of the depth of soil reached by the roots.
	Per cent.
Excessive	More than 1.5
Very strong	1.0-1.5
Strong	.8-1.0
Medium strong	.6- .8
Medium	.4- .6
Weak	.1- .4
Negligible	Less than .1

[1] These terms are used in order to avoid a constant repetition of figures of percentages in discussing the alkali relations of crop plants.

As shown on a preceding page, it is the concentration of the soil solution within reach of the roots and not the mere quantity of salts present which actually determines the effect of alkali upon plant growth. But as the soil moisture and hence the strength of the solution are extremely variable, alkali land can be classified only on the basis of percentages of the salts to the dry weight of the soil. In using the above classification in discussing the resistance of plants it is assumed that the soil contains a degree of moisture favorable for the growth of the crop in question; also, that the soil is not extremely sandy, for sandy soils hold much less water than loams or clays and hence a given percentage of alkali produces a more concentrated solution in very light soils.

CROP PLANTS ADAPTED TO THE DIFFERENT GRADES.

The limits given are those for crop production and take into consideration such matters as quality of the grain in cereals, of the fiber in cotton, and of sugar content in sugar beets. The term "good crop" implies an approach to the normal production in alkali-free soils, while "fair crop" implies a product giving a reasonable return on the investment, the relatively low value of the land being considered. The limits as given apply to the maturing crop. For germination and growth during the seedling stage the limits will in many cases be considerably lower.

It should be understood that any classification of crops on the basis of their alkali resistance can be applicable only in a very general way, owing to the varying nature of the conditions (discussed in the preceding sections of this bulletin) which determine resistance in any particular locality or soil. The classification applies most closely where the alkali is of the sulphate type. In localities where common salt (sodium chlorid) forms the bulk of the alkali it will be found that most of the crop plants mentioned succeed best at the lower limits of the respective grades. If an appreciable quantity of black alkali is present, the classification will not hold good at all.

In spite of these limitations, it is believed that the following grouping will be useful as a guide to the selection of crops for testing in alkali soils, since the comparative tolerance of the different plants is sufficiently indicated. Further details regarding the alkali resistance of each crop are given under "Alkali resistance of the different crop plants" (pp. 18–30).

Excessive alkali.—Only a very few useful plants can be depended upon to grow where more than 1.5 per cent of the dry weight of the soil consists of alkali salts. Chief among these are the native and foreign saltbushes and related plants of the goosefoot family (Chenopodiaceæ), which are of some value as forage. Certain native grasses, notably salt-grass (*Distichlis spicata*), which affords pasturage of rather inferior quality, can endure more than 1.5 per cent of white alkali. Sugar-beet plants can grow in the presence of as much as 2.5 per cent, but the roots produced are small, the sugar content low, and the ash content of the juice too high. Among fruit trees the date palm is the only species that is at all likely to succeed.

Very strong alkali.—Where there is not more than 1.5 per cent of salts in the soil, if other conditions are exceptionally favorable sugar beets may give a fair crop, although they are not to be recommended for soils containing this quantity of alkali. The date palm is still the only fruit tree which can be expected to yield fruit of good quality. Pomegranate bushes will grow, but will probably not yield edible fruit.

Strong alkali.—Under otherwise favorable conditions the following plants may be expected to give fair crops in soils holding not more than 1 per cent of salts: Sugar beets, western wheat-grass, awnless brome-grass, and tall meadow oat-grass.

Medium-strong alkali.—In soils that contain not more than 0.8 per cent of salts, good crops may be grown of the following meadow and pasture grasses: Western wheat-grass, brome-grass, tall meadow oat-grass, and, when once established, of Italian ray-grass (or rye-grass), meadow fescue, and slender wheat-grass; also, of sugar beets and common or foxtail millet. Fair crops of rape, kale, sorgo, and barley hay may be grown.

Medium alkali.—The following plants should give good crops in soils containing not more than 0.6 per cent of salts: Sorgo, common or foxtail millet, rape, kale, redtop, timothy, orchard grass, barley, rye, cotton, and asparagus. Fair crops are possible of milo, kafir, proso millet, wheat, oats, emmer, alfalfa, field peas, sweet clover, vetches, and flax. Among orchard crops, pears and possibly figs may be grown if other conditions are favorable.

Weak alkali.—Where the soil contains not more than 0.4 per cent of salts, good crops may be expected of nearly all forage plants and of the cereals except corn. Among truck crops, the beet, cabbage, cauliflower, celery, eggplant, kale, spinach, Irish potato, sweet potato, tomato, and watermelon are the most likely to succeed. Grapes of the European type (Vinifera) can be produced if other conditions are favorable.

Negligible alkali.—Practically all field-crop plants can be expected to produce profitably in the presence of less than 0.1 per cent of white alkali if other conditions are favorable. Few of the truck and orchard crops are likely to suffer.

As previously stated, however, the limits for all of these crops will be lower if the alkali is largely accumulated near the surface of the soil, especially at the time of seeding. Moreover, less alkali can be endured if the soil is very sandy or if an appreciable quantity of black alkali is present. The existence of other unfavorable conditions, such as a deficiency of necessary plant-food elements in the soil, diseases of various kinds, and in the case of trees and other deep-rooted plants a high water table, may lower the limits of tolerance below what would be the case where alkali is the only injurious factor.

In Table II lists are given of the crop plants which are most likely to succeed on land containing different grades of alkali. Only such plants as may be expected to give at least a fair crop in the absence of the unfavorable conditions mentioned in the preceding paragraph are included under each grade.

TABLE II.—*Crop plants which are most likely to succeed in the presence of different grades of alkali.*

Weak alkali (0.1 to 0.4 per cent).	Medium alkali (0.4 to 0.6 per cent).	Medium strong alkali (0.6 to 0.8 per cent).	Strong alkali (0.8 to 1 per cent.)	Sugar beets. Western wheat-grass. Awnless brome-grass. Tall meadow oat-grass.
				Meadow fescue. Italian ray-grass. Slender wheat-grass. Foxtail millet. Rape. Kale. Sorgo. Barley (hay crop).
				Redtop. Timothy. Orchard grass. Cotton. Asparagus. Wheat (hay crop). Oats (hay crop). Barley (grain crop). Rye (grain crop).
				Wheat (grain crop). Emmer (grain crop). Oats (grain crop). Kafir. Milo. Proso millet. Alfalfa. Field peas. Vetches. Horse bean. Sweet clover.

CONSIDERATIONS GOVERNING THE CHOICE OF CROPS FOR ALKALI LAND.

The owner of alkali land who wishes to select crop plants for trial from the preceding list should first make a careful study of his situation, finding out all he can about the quantity of alkali present in his land, the height of the water table, and the opportunities for drainage and for washing out the salts, at least from the surface soil. He should also take into consideration the climate of his region, which necessarily limits the number of available crops, and the local marketing conditions, which determine what crops can be profitably disposed of.

If it should prove practicable to reclaim the land by flooding and drainage, the question will arise, What crops can be grown to best advantage during the progress of the work? If the soil is in poor physical condition or is deficient in humus or nitrogen, alkali-resistant green-manure crops should be tried whether or not the land is to be reclaimed by drainage. If immediate reclamation is not feasible, crops and tillage methods should be preferred which help to check evaporation and prevent the further accumulation of salts in the topsoil. If the water table is high and drainage is impracticable, shallow-rooted plants must be selected.

The following paragraphs contain suggestions as to the crop plants best adapted to these different conditions.

EXAMPLES OF CLIMATIC LIMITATIONS.

Many alkali-resistant plants, such as cotton, rice, and the date palm, can be grown only in the warmer part of the country. Another case where climate plays an important part in deciding the choice of crop plants for alkali land is that of the Pacific Coast States, where the winter is mild and most of the rainfall occurs at that season. This allows certain crops to be grown on land containing too much alkali to permit success with the same crops in summer (see p. 10). The cereals—barley, wheat, etc.—often give good results under these conditions, especially when grown for hay. Various leguminous forage plants (for example, vetches and horse beans) can also be recommended as winter crops for moderately alkali land in the States mentioned. Similar results can doubtless be obtained in Arizona and adjacent regions of low rainfall, provided sufficient water is available for frequent irrigation in winter.

FORAGE PLANTS USUALLY PREFERABLE.

It has been pointed out (p. 11) that many plants can tolerate a quantity of alkali which impairs the product for which they are grown to such a degree as to render them worthless as crops. On the other hand, the majority of forage plants, being grown chiefly for their leaves and stems, are successful crops wherever the plants themselves can make a good growth. The meadow and pasture grasses, sorgos, common or foxtail millet, and rape are among the most satisfactory crops for land containing more than one-half of 1 per cent and less than 1 per cent of alkali, while such leguminous forage plants as alfalfa, vetches, Canada peas, and sweet clover may be expected to succeed in the presence of any quantity less than one-half of 1 per cent when a stand is once obtained.

RECLAMATION CROPS.

Such crop plants should be selected as can best endure the frequent floodings given alkali land that is being reclaimed. Sorgo is the most generally valuable crop for this purpose. Rice is extensively used in Egypt as a reclamation crop and can be recommended for localities in the United States which have a suitable climate and an ample water supply. When the reclamation is approaching completion it is the custom in Egypt to seed the land to the clover known as berseem, and if a good stand is obtained the soil is considered sufficiently free from salts for the growing of cotton, the principal crop of that country. As berseem succeeds well only as a winter crop in regions that are almost free from frost, its usefulness in the United States will necessarily be very restricted.[1]

The idea is current in some localities that alkali land can be reclaimed merely by growing certain resistant plants, such as saltbushes and sugar beets. As a matter of fact, the plants mentioned when grown on alkali soils do take up considerable quantities of salts, as is shown by chemical analysis of their ash. The salts absorbed are, of course, removed from the land if the crop itself is removed. Yet the quantity of alkali taken out by the plants is usually so small in proportion to the total amount in the soil that it is very doubtful whether land containing any considerable quantity of salts could be permanently reclaimed by the removal of many successive crops.

GREEN-MANURE CROPS.

Alkali soils are apt to be deficient in humus, and, especially if any black alkali is present, they tend to become puddled when wet and to form a hard, baked surface when dry, offering much resistance to the penetration of water. The tilth of such land can often be improved by disking in barn manure or plowing under a green-manure crop where such a crop can be grown. The effect of thus incorporating organic matter is to loosen the surface, making it easier for water to penetrate the soil and to wash the salts downward. Furthermore, the loose material acts as a mulch, checking evaporation and hence retarding the return of the alkali to the surface. It is also probable that conditions more favorable to the accumulation of nitrogen can be established by increasing the supply of organic matter.

The crop plants suitable for green manure which are most likely to succeed where the alkali exceeds one-half of 1 per cent are sorgo, millet, barley, rye, rape, and kale. Where there is less than one-half of 1 per cent of alkali, certain leguminous plants—alfalfa, sweet clover, Canada peas, vetches, and horse beans—are likely to give good results if a stand can be secured. Where they can be grown, leguminous plants are preferable because they produce an immediate increase in the supply of nitrogen.

CROPS FOR ALKALI LAND NOT BEING RECLAIMED.

Other things being equal, those crop plants should be selected which leave the land in the best condition for succeeding crops.

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[1] For further information concerning crops grown in Egypt on alkali land that is being reclaimed, see the Yearbook of the United States Department of Agriculture for 1902, pp. 573–588.

This depends upon the character of the plant itself and of the cultural methods used in growing it. Thus, alfalfa, if a stand can be obtained, will shade the ground more or less effectively at all times, reducing evaporation and thereby helping to prevent the salts from accumulating at the surface of the soil. On the other hand, the small grains (wheat, barley, oats, etc.) are less efficient in this respect and unless the stubble is disked or plowed up immediately after harvest and a soil mulch established, the intense evaporation from the hardened, unshaded surface will result in accumulating the alkali in the topsoil.

Intertilled crops, such as sugar beets and cotton, are desirable for land containing a moderate quantity of alkali, provided that a cultivation is given promptly after every rainfall or irrigation in order to check evaporation and thus prevent the return of the alkali to the surface. Even in the case of crops which are ordinarily seeded broadcast, it may be advantageous on alkali land to put in the seed with a drill, leaving enough space between the rows to permit cultivation.

On land containing too much alkali for crop production by ordinary methods, a stand can sometimes be obtained by planting the seed at the bottom of furrows and running water through the furrows at frequent intervals. This method has been successfully used with sorghum in the Southwest. It has the effect of washing down what alkali is present at the bottoms of the furrows, but meanwhile the soil between them is subirrigated and the salts accumulate at the summits of the ridges. The same thing happens when orchards on alkali land are furrow-irrigated. The result in both cases is that ultimately the alkali condition of the topsoil is aggravated unless the land is occasionally leveled and heavily flooded in order to wash down the surface accumulation of salts.

CROPS FOR ALKALI LAND HAVING A HIGH WATER TABLE.

Shallow-rooted plants should be selected for alkali land having a high water table. In many cases the best use that can be made of such land is to convert it into permanent meadow or pasture, the grasses being shallow-rooted plants and also more or less tolerant of alkali. In addition to the native grasses which often occur naturally on such land, most of the cultivated grasses are well adapted to this purpose (see pp. 19–20). As catch crops for land of this character when only a moderate quantity of alkali is present, the small grains (barley, rye, oats, and wheat) will give at least a hay crop, especially in years of heavy rainfall.

ALKALI RESISTANCE OF THE DIFFERENT CROP PLANTS.

In the following pages many of the crop plants grown in the Western States are discussed in connection with their behavior on alkali soils, the plants being arranged under the crop classes—forage plants, cereals, etc.—to which they belong instead of strictly in the order of their relative tolerance for alkali.

FORAGE PLANTS.

As a rule, forage plants are likely to give the most satisfactory results on alkali land, and among them hay and pasture plants which are grown principally for their stems and leaves are to be preferred to such plants as kafir, milo, and proso millet, in which seed production is an important feature.

In many parts of the West, barley, oats, and even wheat are extensively grown as hay crops, but to avoid repetition the relations of these plants to alkali will be discussed under the heading "Cereals."

Meadow and Pasture Grasses.

No class of cultivated plants can be more safely recommended for alkali land than the meadow and pasture grasses. Subirrigated lands in valley bottoms that carry considerable salts can be utilized in no better way than as permanent grass meadows and pastures.

Western wheat-grass grows wild in many parts of the western United States, where it is highly esteemed for hay and pasturage.[1] It is frequently found occurring naturally in alkali land. In field experiments carried on by the writer it proved to be more tolerant of alkali than any of the other grasses tested. This plant can make some growth in the presence of 2 per cent of white alkali in the first 2 feet of the soil, and seed can be ripened in the presence of 1 per cent. Where the alkali is only medium strong (0.65 per cent) it has been found to make as good growth as in soil free from alkali.

Unfortunately, this grass is often a poor seed producer, since the heads are very often diseased with ergot. The percentage of germination of the seeds produced is also low, and the plants are very slow in starting growth, two or three years being required to get a full stand. Western wheat-grass should always be seeded in mixture with some of the other alkali-resistant grasses here mentioned.

Awnless brome-grass (*Bromus inermis*) and tall meadow oat-grass rank next to western wheat-grass in their tolerance of alkali. The growth of brome-grass is unhindered where the alkali is of the medium grade (0.5 per cent). In fact, this grass can make excellent growth and seed production where the alkali is medium strong (0.7 per cent), and it has been observed to ripen some seed in the presence of very strong alkali (1.5 per cent). Tall meadow oat-grass is apparently fully as tolerant as smooth brome-grass, being able to make a fair growth and ripen seed in the presence of strong alkali (1 per cent).

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[1] The high feeding value of western wheat-grass hay is shown by the results of analyses quoted in Bulletin 196, Bureau of Plant Industry, 1910, p. 30.

These three species—western wheat-grass, awnless brome-grass, and tall meadow oat-grass—can safely be recommended for land containing not more than 1 per cent of white alkali. Since the first two are rather slow-growing grasses, it will be advantageous to seed them in mixture with tall meadow oat-grass or with some of the species mentioned in the next paragraph.

Other grasses which have been tested and found to be adapted to alkali land, although somewhat less resistant than those just mentioned, are tall meadow fescue, Italian ray-grass or rye-grass, slender wheat-grass, redtop, orchard grass, and timothy, their tolerance for alkali being in about the order named, beginning with the most resistant. All of these species should give good results where the alkali is not more than of the medium grade, and most of them will usually succeed in the presence of medium-strong alkali if the salts are pretty evenly distributed throughout the depth of soil reached by the roots of the plants.

Italian ray-grass can be recommended as a lawn grass for moderately alkali land, although being rather short lived it has to be reseeded frequently.

In seeding grasses on alkali land care should be taken to insure a seed bed relatively free from salt, either by planting immediately after heavy rains or by flooding before seeding. The small seeds of most of the species have little chance of success where there is a heavy accumulation of salts at the surface of the soil.

Some of the native grasses of the western United States are among the most alkali resistant of plants. Western wheat-grass has already been discussed. The familiar salt-grass (Distichlis) is found in nearly all localities where alkali soils occur, and its presence is usually a reliable indicator that the soil contains at least a medium quantity of salts. It often covers the ground with a dense sod and affords considerable pasturage, although of a quality that is probably too inferior to warrant planting where this grass does not naturally occur.

Sorghums.

There is a general and well-founded belief in regions where alkali soils occur that the sorghums are among the best-adapted forage plants for this type of land. They lend themselves readily to culture on alkali land that is being reclaimed, since they can endure a great deal of flooding. It is the practice in some parts of the Southwest to seed sorghum at the bottoms of furrows, down which water is run at frequent intervals. This keeps the soil relatively fresh around the seeds and the roots of the young plants and often permits a stand to be had in land containing too much alkali to produce a crop if ordinary methods of planting are followed.

The sorgos, or saccharine sorghums, being grown largely for their leaves and stalks, are likely to give more satisfactory results on alkali land than the milos and kafirs, in which seed production is more important. Amber sorgo can make a fair growth and develop heads in the presence of medium-strong white alkali, and a good crop may be expected in the presence of medium alkali provided other conditions are favorable. In the germinating and seedling stage the plants do almost as well in the presence of medium-strong white alkali as in soil practically free from these salts. In fact, no other crop plant with which the writer has experimented has shown so great a degree of resistance in this stage of growth. Sorgo is also apparently more resistant to black alkali than are the majority of crop plants.

The kafirs and milos can endure as much alkali as the saccharine sorghums, so far as the growth of the plants is concerned, but it is inadvisable to attempt to grow them for seed production where more than a medium quantity occurs.

Millets.

Common or foxtail millet is an excellent crop for moderately alkali land. A good crop may be expected where there is not more than a medium quantity of white alkali. The germination of the seeds and the growth of the plants during the seedling stage are not materially hindered by this quantity of salts if there is not too great an accumulation at the surface of the soil. In the presence of medium-strong alkali a fair crop can be produced, and a limited growth and seed production are possible under otherwise favorable conditions even where strong alkali occurs. One per cent of white-alkali salts in the depth of soil occupied by the roots is probably the extreme limit for seed production, and this quantity is too great for profitable crop production.

The proso or broom-corn millets are also decidedly tolerant of alkali, but as they are grown mainly for their seed it is doubtful whether they are as suitable a crop for such soils as the foxtail millets. The yield of straw on alkali land also appears to be lighter in the case of the prosos. The results of the writer's experiments in the field indicate that the upper limit of the weak grade of white alkali (0.4 per cent) is about the limit for a good crop of proso. Growth and seed production were greatly reduced at the upper limit of the medium grade (0.6 per cent).

Rape and Kale.

Rape and kale, which are extensively used for forage in Europe but are little grown in the western United States, are decidedly tolerant of salts. Essex rape makes a fair growth in the presence of medium-strong white alkali. Where the alkali does not exceed the upper limit of the weak grade (0.4 per cent), the plants can reach full size. Forage kale (the Thousand-Headed variety) appears to be at least equally resistant, making a fair growth in the presence of medium-strong white alkali.

The chief objection to these plants as a crop for alkali land is the difficulty frequently experienced in getting a stand. They appear to be decidedly more sensitive than the sorghums and millets while in the germinating and seedling stages. The small and delicate seedlings also have great difficulty in breaking through the crust that forms on the surface of certain types of alkali land when allowed to become too dry. Care should therefore be taken in seeding these crops on such land to first wash the salt out of the surface soil and to irrigate frequently enough to prevent a hard crust forming until the plants are sufficiently large to shade the ground. With these precautions to insure a stand, rape and kale are likely to prove useful as green-manure crops for alkali soils, which are often deficient in humus.

Saltbushes.

The saltbushes (species of Atriplex)[1] are among the most characteristic of the native plants of the western United States which grow naturally on alkali land. In fact, the presence of many of the species is a reliable indicator that the soil contains salts in sufficient quantity to injure the majority of cultivated plants. Saltbushes are of more or less value as an element of the natural pasturage or range of the western United States, being browsed by cattle and sheep, especially when grass is scarce. While it has been demonstrated that the North American species can be successfully seeded on moist alkali land,[2] it has not been proved that the enterprise would be a profitable one. Some of the Australian saltbushes were rather extensively tested a few years ago by the California Agricultural Experiment Station, and were found capable of tolerating an excessive quantity of alkali, in one case as much as 4 per cent in the first 4 feet of the soil. But it has not been demonstrated that the value of the crop will warrant the expense of getting a stand, and the saltbushes have not been taken up by farmers to any important extent. The Australian species will probably succeed only in regions having a mild winter, like California, Arizona, and possibly southern Nevada and parts of New Mexico and Texas.

The value of some of the larger-growing saltbushes for making hedges and windbreaks in alkali land is discussed on another page.

Leguminous Forage Plants.

Plants of the pea family (Leguminosæ) are generally sensitive to alkali, as is indicated by the fact that very few species of this large and widely distributed family grow naturally in salty soils. Nevertheless, some of these plants are fairly tolerant and can be grown in land carrying a moderate quantity of salts—provided the conditions are otherwise favorable. Unless the topsoil is practically free from alkali at the time of seeding, a greater measure of success is likely to be had with large-seeded species, such as field peas, vetches, and horse beans, than with small seeds like those of alfalfa and clover. The Leguminosæ are very sensitive to sodium carbonate, and their culture should not be attempted if black alkali is present in appreciable quantity. Where the soil contains not more than a medium quantity of white alkali, alfalfa, berseem (Egyptian clover), sweet clover, Canada field peas, horse beans, and some of the vetches may be grown with fair success. Where these plants can be grown they will be found beneficial to alkali soils if plowed in, since the material thus added not only improves the tilth and increases the supply of humus, which such soils often lack, but also furnishes nitrogen for the use of succeeding crops.

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[1] The North American and Australian saltbushes are discussed by Mr. J. G. Smith in the Yearbook of the United States Department of Agriculture for 1898, pp. 535 to 550, with special reference to their utility on alkali land; also by Dr. P. B. Kennedy, in Farmers' Bulletin 108, 1900, entitled "Saltbushes."

[2] In Bulletin 63, Wyoming Agricultural Experiment Station, 1904, methods of planting are described on page 17.

Alfalfa.—Being the most extensively grown forage crop of the western United States, alfalfa has received more attention than any other leguminous plant with respect to its relations to alkali soil. It is difficult to start in even moderately alkali land in case the salts are largely accumulated in the surface soil, but if seeded just after a heavy rain or irrigation the taproots of the young plants will speedily penetrate to a considerable depth and by the time evaporation has brought the salts back to the surface the feeding roots may be largely out of reach of the surface accumulations. It is a common experience in the West to see old plants of alfalfa growing vigorously in the presence of surface accumulations of salts that would absolutely prevent getting a stand. In such cases the greater part of the alkali must have risen after the alfalfa was seeded. If a stand can be obtained alfalfa is well adapted to preventing excessive accumulation of salts in the topsoil, owing to the shade constantly afforded by this crop. It has been observed that alfalfa can flourish for years in land where, if the stand is plowed up, the salts quickly accumulate near the surface in such large quantity that grain can not be successfully seeded.

In the germinating and seedling stage alfalfa has given satisfactory results where the alkali in the first 6 inches of the soil was at the lower limit of the medium grade (0.4 per cent), with no black alkali present. Young alfalfa is exceedingly sensitive to black alkali, but Prof. Hilgard states that if only a slight amount of sodium carbonate is present a stand can sometimes be obtained if gypsum or land plaster is sown with the seed.

Alfalfa when once established can endure the upper limit of the medium grade of white alkali (0.6 per cent) if the salts are mostly sulphates. If chlorids form a large proportion of the alkali the lower limit of this grade (0.4 per cent) is usually about the limit for a healthy growth. But where the soil is very sandy as little as 0.2 per cent of the chlorid type of alkali may injure the plants, the soil solution being more concentrated in a sandy than in a loam or clay-loam soil.

The percentages mentioned represent the average limits for the profitable production of alfalfa in the presence of different types of alkali. Occasional individual plants are more resistant and have been observed to ripen seed in the presence of as much as 1 per cent where the alkali was largely common salt (sodium chlorid).

Field peas.—Next to alfalfa the Canada field pea is the most important leguminous forage crop grown in the western United States. In the germinating and seedling stages the upper limit of the weak grade of alkali (0.4 per cent) marks about the limit of tolerance for this plant. Where white alkali of the sulphate type does not exceed 0.2 per cent of the weight of the soil, germination has been observed to take place as readily as in soil free from alkali. Crop production is possible in the presence of a medium quantity of sulphate alkali (0.5 per cent), and a good crop can be obtained where the alkali does not exceed the lower limit of this grade (0.4 per cent).

Sweet clover.—The white-flowered sweet clover is a common weed in many irrigated districts and often attracts attention because of its luxuriant growth under apparently unfavorable conditions. It is usually avoided by stock on account of the bitter and aromatic flavor of the plant, although it is stated that horses, cattle, and sheep can become accustomed to it and even learn to relish it. Sweet clover is a very efficient nitrogen gatherer and undoubtedly possesses considerable value as a green-manure crop. While it is generally believed that this plant is much more tolerant of alkali than is alfalfa, actual experiments in alkali soils do not bear out this conclusion. The upper limit of the weak grade of white alkali (0.4 per cent) is about the limit for good germination and the production of a heavy crop of sweet clover. But where this percentage of alkali is present in the surface soil it is probably easier to get a stand of sweet clover than of alfalfa. In land having a high water table sweet clover can often be successfully grown where alfalfa will not thrive.

The yellow-flowered sweet clover, or "sour clover," is much more common in the Southwest than the white-flowered species. In Arizona, where it makes most of its growth in winter, this plant is likely to prove useful as a green-manure crop for alkali land of the medium and weak grades.

In considering the desirability of seeding either species of sweet clover, the tendency of these plants to become aggressive field weeds should be borne in mind. It is doubtful whether it would be wise to introduce them into any locality where they are not already abundant.

True clovers.—Little is known about the alkali resistance of the clovers ordinarily grown in the United States—red, white, crimson, and alsike. It is probable that all of these species are rather sensitive.

Berseem, or Egyptian clover, is extensively grown in Egypt as a winter crop on alkali land under reclamation and is used there as an indicator of the degree to which the salts have been washed out of the soil. As soon as a stand of clover can be had it is considered safe to put the land into cotton. Berseem is particularly useful as a reclamation crop because it can endure a great deal of moisture and is not injured by the frequent floodings given land that is being reclaimed. The medium grade of alkali, where sodium chlorid is the principal salt, is believed in Egypt to be about the limit for the successful growth of this clover. Attempts to utilize this plant in the United States have not been very successful. As it is sensitive to frost and apparently also to hot weather its usefulness will be restricted to localities having a very mild winter.

Vetches.—Two species of vetch, the hairy vetch and the scarlet vetch, have been rather thoroughly tested and have proved easier to germinate in alkali soils than any other leguminous plants included in the writer's experiments. Hairy vetch gives a good germination and produces a fair hay crop where alkali of the sulphate type does not exceed the lower limit of the medium grade. Scarlet vetch appears to be at least equally resistant, making a heavy crop in the presence of the medium grade of sulphate alkali. The lower limit of this grade (0.4 per cent) does not appreciably retard the germination and seedling growth of scarlet vetch, and as much as 1 per cent does not prevent germination, although the seedlings grow very slowly at this concentration. It is unlikely that profitable crops can be grown if the alkali exceeds the upper limit of the medium grade (0.6 per cent).

Horse bean.—The horse bean is extensively grown in the Old World as a forage plant. A large-seeded form (the so-called "broad bean") is a favorite table vegetable in Europe. In the United States the plant has been grown only experimentally and appears to succeed best as a winter crop in California and as a summer crop in rather elevated regions, such as eastern Wyoming, where the summer is comparatively cool. It appears to be decidedly more tolerant of alkali than the majority of leguminous plants. The large size of the seeds makes it easier to get a stand in alkali land than is the case with most plants of this family. As it produces a considerable quantity of vegetable matter, the horse bean is worthy of consideration as a green-manure crop for alkali land in localities having a suitable climate. Hot weather soon puts an end to the growth of the plants and causes them to turn black. In soils where the alkali is of the sulphate type the young plants will tolerate medium-strong alkali. Numerous pods are set where the alkali does not exceed the lower limit of the medium grade (0.4 per cent).

SUGAR BEETS.

Sugar beets are undoubtedly the most alkali resistant of the important field crops grown in the western United States. But while the plants can tolerate excessive quantities of salts, it is not profitable to grow them in very strong alkali soils because of the injurious effect of the alkali upon the size of the roots and upon the percentage of sugar and the purity coefficient of the juice. The actual limits for profitable beet growing must be ascertained in each locality by testing the effect of the prevailing type of alkali upon the composition of the roots.

As a rule, a good stand of sugar beets can not be expected if the soil around the germinating seeds and the roots of the young seedlings contains more than the medium grade of white alkali (about 0.5 per cent). One-tenth of this amount of black alkali (sodium carbonate) is probably the greatest quantity which will permit a stand being obtained. Experienced beet growers find that a heavy irrigation previous to planting often makes it possible to secure a stand in alkali land where without this precaution beets could not be successfully started. The subsequent return of the salts to the surface of the soil may not injure the plants, since after the seedling stage is past sugar beets are much more tolerant of alkali.

When once established, sugar beets can be expected to produce a good crop of marketable roots where white alkali (sulphates, chlorids, and bicarbonates) occurs in a quantity not exceeding the medium grade. Even where the alkali is medium strong or strong, a crop of beets suitable for sugar manufacture can sometimes be made if favorable moisture conditions are maintained and the soil is not too sandy. A much smaller quantity of black alkali will prevent a crop, although sugar beets will apparently endure more sodium carbonate than will the great majority of crop plants.

The fact that the beet is a cultivated crop recommends it for growing on alkali land, since intertillage is one of the most effective methods of keeping the salts from accumulating at the surface of the soil, provided the field is cultivated as soon as possible after every rainfall or irrigation.

CEREALS.

The small grains (wheat, emmer, barley, oats, and rye) can not be recommended for land containing more than weak alkali except when grown as a hay crop (see p. 16). While the plants can grow in the presence of a considerable quantity of salts, the quality of the grain is likely to be inferior, the kernels being small and more or less shriveled. Furthermore, unless the land is plowed immediately after harvest an accumulation of salts at the surface of the soil is favored, since grain stubble affords little or no protection against evaporation and the baking of the soil surface. The land is thus rendered less fit for succeeding crops. Corn is decidedly sensitive and should not be grown at all on alkali land. Rice, being able to endure a great deal of flooding, may be used as a reclamation crop in regions having a suitable climate.

Wheat for milling purposes should not be grown in land containing more than weak white alkali. A good hay crop with a fair yield of grain can be obtained in medium white alkali if the soil is a loam or clay loam and the moisture conditions are favorable. If black alkali is present, the limits will, of course, be very much lower.

Emmer appears to have about the same degree of alkali resistance as wheat.

Barley is more tolerant of alkali. The crop can be grown in medium white-alkali land, although near the upper limit of this grade it is unlikely that the high quality of grain required for brewing purposes can be obtained. In loam or clay-loam soils, if a favorable moisture content is maintained, barley can be grown as a hay crop even when the alkali reaches the medium-strong grade, provided the alkali content of the topsoil at the time of seeding does not exceed the medium grade. The limits in the presence of black alkali are much lower, although barley appears to be decidedly superior to wheat in tolerance of sodium carbonate.

For oats, under ordinary conditions the medium grade of white alkali is about the limit for a profitable hay crop and a fair yield of grain. A full crop and high quality of grain can not be expected if the alkali exceeds the upper limit of the weak grade unless other conditions are exceptionally favorable.

Rye is almost, if not quite, equal to barley in tolerance of alkali. A fair crop of grain can be obtained in the presence of the medium grade of white alkali. Rye is well adapted for growing as a green-manure crop on alkali land, although a good stand can not be expected if the topsoil at the time of seeding contains more than medium alkali.

Corn is decidedly more sensitive than the small grains and is not to be recommended for alkali soils. In Egypt, where extensive areas of alkali land occur and where the people have long been familiar with this problem, corn is said to fail on land that will produce good crops of rice and cotton. Experiments in the United States indicate that even where the alkali is only of the weak grade a good crop of corn can not be expected.

Rice is regarded as sensitive to brackish water in Louisiana and Texas, but in Egypt it is one of the principal crops grown on alkali land that is being reclaimed by drainage and flooding. A good crop has been observed in that country where the alkali in the soil (mainly sodium chlorid) was of the strong grade (1 per cent). It does not follow that the rice plant is actually much more resistant than other cereals, for the frequent flooding of land under reclamation keeps the soil solution relatively dilute provided the irrigation water itself has a low salt content. In a recent publication of the Texas Agricultural Experiment Station[1] it is stated that the irrigation of rice with water containing as much as 0.3 per cent of sodium chlorid is likely to injure the crop and that water containing as much as 0.5 per cent should never be used.

FIBER PLANTS.

Cotton.

Cotton is not at present extensively grown in parts of the United States where alkali soils occur, but the prospects seem good that it will become an important crop under irrigation in the Southwest. Cotton plants are decidedly tolerant of alkali, making a fair growth in the presence of very strong alkali where sodium chlorid is the principal salt. But the limits for a profitable crop are much lower, since it has been observed that a quantity of alkali that is too small to appreciably hinder the growth of the plants has an injurious effect upon the number and size of the bolls and retards their ripening, besides impairing the length and fineness of the fiber. So far as can be judged from present information it is inadvisable to grow Egyptian and other superior types of cotton where chlorid alkali of more than the weak grade occurs. Profitable crops of short-staple Upland varieties, in which the quality of the fiber is less important, may very likely be produced in the presence of medium alkali of this character.

Cotton, being intertilled while the plants are young and shading the ground very effectively after the middle of the summer, is a desirable crop for moderately alkali land in the southern part of the arid region. This crop requires less irrigation, especially during the early stages of growth, than almost any other grown in that region. It is all the more important, therefore, that thorough cultivation be given in order to prevent the accumulation of the salts at the surface of the soil.

Flax.

Flax has been observed in unirrigated land of North Dakota to make a fair crop where the surface foot of the soil contained sulphate alkali of the medium grade, and a good crop at the lower limit of this grade (0.4 per cent). The presence of an excessive quantity of salts in the soil below the first foot had apparently no injurious effect.

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[1] Fraps, G. S. The effect of salt water on rice. Bulletin 122, Texas Agricultural Experiment Station, 1909.

GARDEN VEGETABLES AND TRUCK CROPS.

Only scanty data are available for forming a conclusion as to what garden vegetables are most tolerant of alkali. It is decidedly inadvisable in the present state of knowledge to grow any truck crop on a large scale in alkali soil. The following suggestions are intended for the farmer whose land contains more or less salts and who desires to grow vegetables in a small way for home use.

Asparagus is generally given the first rank among garden vegetables in tolerance of alkali and when grown in eastern soils appears to be actually benefited by applications of common salt (sodium chlorid). White alkali of the medium grade does not prevent the successful growing of asparagus. Onions are also reported to be adapted to white-alkali land of the medium grade. Celery is said to do well in California in the presence of the weak grade of alkali where sodium chlorid is the principal salt.

Other truck crops which are worthy of trial on alkali land of the medium and weak grades, although little is known about their actual degree of resistance, are the globe artichoke, the beet, cabbage, cauliflower, celery, eggplant, kale, spinach, sweet potato, and watermelon.

Irish potato plants make a fair growth in the presence of white alkali of the medium grade, but the tubers produced are too small to be marketable. Where the alkali is near the lower limit of the weak grade, potatoes of good quality can doubtless be produced.

TREES AND SHRUBS.

It is extremely difficult to determine the limits of the alkali resistance of trees, since, in addition to the quantity and kind of salts, the depth of soil in which the alkali is located must be considered in connection with the different kinds of root systems possessed by the different species of trees. A high water table, which is often associated with the presence of alkali, is very injurious to most woody plants.

Fruit Trees and Grapes.

In addition to the matters already mentioned, the effect of the salts upon the keeping quality and flavor of the fruit can not be overlooked in the case of orchard crops. It can only be said in a general way that strong alkali soils should be avoided in planting fruit trees, except the date palm and the pomegranate, which will tolerate considerable quantities of salts. The pear and the fig are also fairly resistant so far as concerns the growth of the trees, but the quality of the fruit suffers if more than a very limited quantity of alkali is present.

The various stone fruits (plum, peach, apricot, cherry, etc.) are considered sensitive to alkali. The same is true of the orange, lemon, and other citrus fruits and of the English walnut.

Grapes of the European class (*Vitis vinifera*) may be expected to ripen fruit of good quality, except for raisin making, wherever the quantity of alkali present is not sufficient to injure the vines themselves.

Ornamental and Shade Trees.

The cottonwoods, so extensively planted along roads and ditches and about houses in the western United States, appear to be fairly tolerant of alkali. *Populus fremonti* is said to be the species best adapted to such land. The black locust, honey locust, and Russian mulberry are also reported to be suitable for planting on soil containing only a moderate quantity of alkali. In portions of the Southwest having a mild winter the list of trees that are likely to succeed in such land can be extended to include the umbrella or china-berry tree (*Melia azedarach*), the Japanese varnish tree (Koelreuteria), the European plane tree (*Platanus orientalis*), the oleander, the Australian beefwoods (species of Casuarina), the Washingtonia palm, and the date palm. The Canary Island palm (*Phoenix canariensis*), a near relative of the date palm, is also probably tolerant of alkali. Of the species of eucalyptus the California Agricultural Experiment Station considers the red gum (*Eucalyptus rostrata*) and the gray gum (*E. tereticornis*) as the best adapted to alkali soils, while the blue gum (*E. globulus*) appears to be the most sensitive of the species tested.

Hedges and Windbreaks.

Of the shrubs and small trees suitable for hedges and windbreaks the Russian olive is one of the species that can best endure the presence of a moderate quantity of salts. Golden willow is also probably worth testing in regions having a severe winter. In the Southwest the pomegranate and tamarisk (*Tamarix gallica*), both of which are decidedly alkali resistant, are excellent hedge plants. The latter is hardy as far north as central-western Nevada. Some of the larger growing saltbushes are very tolerant of alkali and make good hedges. *Atriplex breweri* is already in use as a hedge plant in the coast region of California and *Atriplex lentiformis* is recommended for the purpose in Arizona.[1]

CONCLUSIONS.

The principal conclusions reached in regard to the adaptability of different crop plants to alkali soils and the choice of crops for land of this character may be summed up as follows:

(1) All useful plants are extremely sensitive to black alkali, and the conclusions stated in the following paragraphs do not apply in case an appreciable quantity of sodium carbonate is present.

(2) Practically none of the important field crop plants can be profitably grown where the quantity of white alkali salts (sulphates,

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[1] See Griffiths, David, "The Ornamental Value of the Saltbushes," Circular 69, Bureau of Plant Industry, 1910.

bicarbonates, and chlorids) in the depth occupied by the roots exceeds 1 per cent of the dry weight of the soil. Only a few decidedly resistant species can be expected to give good crops where the quantity exceeds one-half of 1 per cent.

(3) Forage plants, especially such as are grown chiefly for hay and pasturage rather than for seed production, are usually to be preferred for growing in alkali land.

(4) Many of the standard meadow and pasture grasses can be successfully grown where the quantity of alkali within reach of the plant roots forms from one-half of 1 per cent to 1 per cent (0.5 to 1 per cent) of the dry weight of the soil. But a good stand of these small-seeded plants can be obtained only if most of the alkali has been leached out of the surface soil at the time of seeding. This may be accomplished by flooding, or the seeding may be done immediately after heavy rains.

(5) Subirrigated alkali land having a high water table can be utilized by seeding to meadow and pasture grasses, most of which have shallow roots.

(6) Foxtail millet, rape, kale, and sorgo, as well as barley and rye, when grown for hay, will often give fair yields if the quantity of alkali does not exceed the upper limit of the medium-strong grade (0.8 per cent).

(7) Certain leguminous forage plants, notably alfalfa, Canada field peas, sweet clover, and vetches, should give a fair yield where the alkali is not above the medium grade (about 0.5 per cent). Success with these crops depends largely upon planting at a time when the surface soil is relatively free from salt.

(8) Alkali soils which have a tendency to puddle and form a hard crust on the surface can be improved by plowing under green-manure crops where any such crop can be grown. This practice loosens the soil, facilitating the penetration of water and hence the leaching out of the salts. Good crops for this purpose are sorgo, millet, barley, rye, rape, and kale, where the alkali is medium strong or medium; and vetches, Canada field peas, horse beans, and sweet clover, where the alkali is weak.

(9) For alkali land that is being reclaimed by flooding, sorgo is probably the most satisfactory catch crop that can be grown during the progress of the work. In regions where the climate is suitable for its culture, rice is a good crop for this purpose, and the same is true of berseem (Egyptian clover) in localities having a mild winter. All of these crops can endure frequent and heavy applications of water.

(10) The sugar beet is the most resistant of the important crop plants of the western United States, but the quality of the roots for sugar manufacture is impaired by a quantity of alkali that does not hinder the growth of the plants. In the presence of the medium grade of white alkali a profitable crop of beets may usually be

expected, and if other conditions are exceptionally favorable as much as 1 per cent of salts can be tolerated. One-half of 1 per cent in the surface soil at the time of seeding is about the limit for getting a stand. Beets, being an intertilled crop, are well adapted for preventing an accumulation of salts at the surface of the soil, provided a cultivation is given as soon as possible after every rainfall and irrigation.

(11) Of the cereals, barley, rye, oats, wheat, and emmer are fairly tolerant of alkali so far as the plants are concerned, but the presence of more than the weak grade usually prevents the production of well-filled heads and plump grain. If grown in alkali land the stubble should be disked or plowed in immediately after harvest in order to prevent the baking of the ground and the consequent accumulation of salts at the surface. Barley and rye are somewhat more resistant than the other species and may be expected to give a hay crop in the presence of medium alkali and sometimes even of medium-strong alkali. Corn is much more sensitive than the small grains and should not be planted on alkali land.

(12) Cotton is decidedly resistant so far as the growth of the plants is concerned, but good yields of fiber can not be expected where the alkali exceeds the medium grade. Egyptian and other long-staple types in which a high grade of fiber is required should not be grown in the presence of more than weak alkali.

(13) None of the truck crops and garden vegetables can at present be recommended for extensive planting on alkali land. Where it is desired to grow vegetables in a small way for home use, asparagus, onions, celery, beets, spinach, cabbage, cauliflower, kale, eggplant, tomatoes, sweet potatoes, and watermelons may be tested. Of these, asparagus and onions are the most likely to succeed on land containing as much as the medium grade of alkali.

(14) Of fruit trees, only the date palm and pomegranate do well on strong alkali land. If the total salts present do not exceed the lower limit of the medium grade (0.4 per cent), pears, figs, and grapes of the European type (Vinifera) are likely to thrive and bear fruit of fair quality.

(15) The following shade and ornamental trees are reported to be successful in moderately alkali land: Cottonwood, black locust, honey locust, and Russian mulberry. Of trees adapted only to regions having a mild winter the date palm and Washingtonia palm can tolerate considerable alkali, and the umbrella tree, European plane tree, Japanese varnish tree, and some species of eucalyptus are also said to be fairly resistant.

(16) Of shrubs suitable for hedges and windbreaks in alkali land, Russian olive and possibly golden willow, in districts having a severe winter, and tamarisk, pomegranate, and the large-growing salt-bushes, in milder regions, are the most likely to give satisfactory results.

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Issued May 23, 1911.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 447.

BEES.

BY

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In Charge of Bee Culture, Bureau of Entomology.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY,
Washington, D. C., March 4, 1911.

SIR: I have the honor to transmit herewith a manuscript entitled "Bees," by E. F. Phillips, Ph. D., in charge of bee culture in this bureau.

This paper will supersede Farmers' Bulletins 59 and 397. A few new illustrations which add greatly to the value of the paper and some minor alterations in the text are the only changes in this from Farmers' Bulletin 397; but since it is not now the policy of the department to issue revised editions, it is recommended that this bulletin be issued under a new serial number.

In the preparation of this paper the aim has been to give briefly such information as is needed by persons engaged in the keeping of bees, and to answer inquiries such as are frequently received from correspondents of the department. No attempt has been made to include discussions of bee anatomy, honey plants, or the more special manipulations sometimes practiced, such as queen rearing. The discussion of apparatus is necessarily brief.

Respectfully,

L. O. HOWARD,
Entomologist and Chief of Bureau.

HON. JAMES WILSON,
Secretary of Agriculture.

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BEES.

INTRODUCTION.

Beekeeping for pleasure and profit is carried on by many thousands of people in all parts of the United States. As a rule, it is not the sole occupation. There are, however, many places where an experienced bee keeper can make a good living by devoting his entire time and attention to this line of work. It is usually unwise to undertake extensive beekeeping without considerable previous experience on a small scale, since there are so many minor details which go to make up success in the work. It is a good plan to begin on a small scale, make the bees pay for themselves and for all additional apparatus, as well as some profit, and gradually to increase as far as the local conditions or the desires of the individual permit.

Bee culture is the means of obtaining for human use a natural product which is abundant in almost all parts of the country, and which would be lost to us were it not for the honey bee. The annual production of honey and wax in the United States makes apiculture a profitable minor industry of the country. From its very nature it can never become one of the leading agricultural pursuits, but that there is abundant opportunity for its growth can not be doubted. Not only is the honey bee valuable as a producer, but it is also one of the most beneficial of insects in cross-pollinating the flowers of various economic plants.

Beekeeping is also extremely fascinating to the majority of people as a pastime, furnishing outdoor exercise as well as intimacy with an insect whose activity has been a subject of absorbing study from the earliest times. It has the advantage of being a recreation which pays its own way and often produces no mean profit.

It is a mistake, however, to paint only the bright side of the picture and leave it to the new bee keeper to discover that there is often another side. Where any financial profit is derived, beekeeping requires hard work and work at just the proper time, otherwise the surplus of honey may be diminished or lost. Few lines of work require more study to insure success. In years when the available nectar is limited, surplus honey is secured only by judicious manipulations, and it is only through considerable experience and often by expensive reverses that the bee keeper is able to manipulate properly to save his crop. Anyone can produce honey in seasons of plenty, but these do not come every year in most locations, and it takes a good bee keeper to make the most of poor years. When, even with the best of manipulations, the crop is a failure through lack of nectar, the bees must be fed to keep them from starvation.

The average annual honey yield per colony for the entire country, under good management, will probably be 25 to 30 pounds of comb honey or 40 to 50 pounds of extracted honey. The money return to be obtained from the crop depends entirely on the market and the method of selling the honey. If sold direct to the consumer, extracted honey brings from 10 to 20 cents per pound, and comb honey from 15 to 25 cents per section. If sold to dealers, the price varies from 6 to 10 cents for extracted honey and from 10 to 15 cents for comb honey. All of these estimates depend largely on the quality and neatness of the product. From the gross return must be deducted from 50 cents to $1 per colony for expenses other than labor, including foundation, sections, occasional new frames and hives, and other incidentals. This estimate of expense does not include the cost of new hives and other apparatus needed in providing for increase in the size of the apiary.

Above all it should be emphasized that the only way to make beekeeping a profitable business is to produce only a first-class article. We can not control what the bees bring to the hive to any great extent, but by proper manipulations we can get them to produce fancy comb honey, or if extracted honey is produced it can be carefully cared for and neatly packed to appeal to the fancy trade. Too many bee keepers, in fact, the majority, pay too little attention to making their goods attractive. They should recognize the fact that of two jars of honey, one in an ordinary fruit jar or tin can with a poorly printed label, and the other in a neat glass jar of artistic design with a pleasing, attractive label, the latter will bring double or more the extra cost of the better package. It is perhaps unfortunate, but nevertheless a fact, that honey sells largely on appearance, and a progressive bee keeper will appeal as strongly as possible to the eye of his customer.

LOCATION OF THE APIARY.

In choosing a section in which to keep bees on an extensive scale it is essential that the resources of the country be known. Beekeeping is more or less profitable in almost all parts of the United States, but it is not profitable to practice extensive beekeeping in localities where the plants do not yield nectar in large quantities. A man who desires to make honey production his business may find that it does not pay to increase the apiaries in his present location. It may be better to move to another part of the country where nectar is more abundant.

The location of the hives is a matter of considerable importance. As a rule it is better for hives to face away from the prevailing wind and to be protected from high winds. In the North, a south slope is desirable. It is advisable for hives to be so placed that the sun will strike them early in the morning, so that the bees become active early in the day, and thus gain an advantage by getting the first supply of nectar. It is also advantageous to have the hives shaded during the hottest part of the day, so that the bees will not hang out in front of the hive instead of working. They should be so placed that the bees will not prove a nuisance to passers-by or disturb live stock. This latter precaution may save the bee keeper considerable trouble, for bees sometimes prove dangerous, especially to horses. Bees are also sometimes annoying in the early spring, for on their first flights they sometimes spot clothes hung out to dry. This may be remedied by having the apiary some distance from the clothes-drying yard, or by removing the bees from the cellars on days when no clothes are to be hung out.

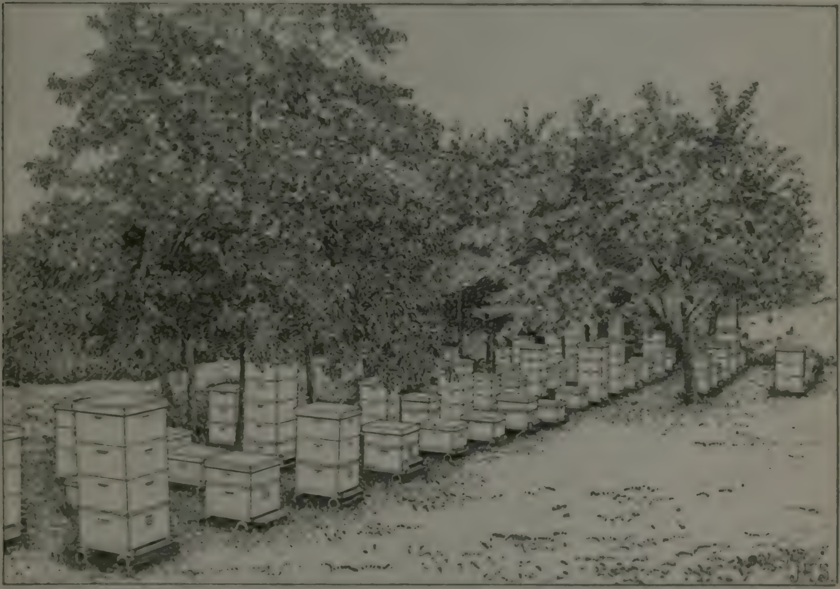

FIG. 1.—A well-arranged apiary.

The plot on which the hives are placed should be kept free from weeds, especially in front of the entrances. The grass may be cut with a lawn mower, but it will often be found more convenient and as efficient to pasture one or more head of sheep in the apiary inclosure.

The hives should be far enough apart to permit of free manipulation. If hives are too close together there is danger of bees entering the wrong hive on returning, especially in the spring.

These conditions, which may be considered as ideal, need not all be followed. When necessary, bees may be kept on housetops, in the back part of city lots, in the woods, or in many other places where the ideal conditions are not found. As a matter of fact, few apiaries are perfectly located; nevertheless, the location should be carefully planned, especially when a large number of colonies are kept primarily for profit.

As a rule, it is not considered best to keep more than 100 colonies in one apiary, and apiaries should be at least 2 miles apart. There are so many factors to be considered, however, that no general rule can be laid down. The only way to learn how many colonies any given locality will sustain is to study the honey flora and the record of that place until the bee keeper can decide for himself the best number to be kept and where they shall be placed.

The experience of a relatively small number of good bee keepers in keeping unusually large apiaries indicates that the capabilities of the average locality are usually underestimated. The determination of the size of extensive apiaries is worthy of considerable study, for it is obviously desirable to keep bees in as few places as possible, to save time in going to them and also expense in duplicated apparatus. To the majority of bee keepers this problem is not important, for most persons keep but a small number of colonies. This is perhaps a misfortune to the industry as a whole, for with fewer apiaries of larger size under the management of careful, trained bee keepers the honey production of the country would be marvelously increased. For this reason, professional bee keepers are not favorably inclined to the making of thousands of amateurs, who often spoil the location for the honey producer and more often spoil his market by the injudicious selling of honey for less than it is worth or by putting an inferior article on the market.

Out apiaries, or those located away from the main apiary, should be so located that transportation will be as easy as possible. The primary consideration, however, must be the available nectar supply and the number of colonies of bees already near enough to draw on the resources. The out apiary should also be near to some friendly person, so that it may be protected against depredation and so that the owner may be notified if anything goes wrong. It is especially desirable to have it in the partial care of some person who can hive swarms or do other similar things that may arise in an emergency. The terms under which the apiary is placed on land belonging to some one else is a matter for mutual agreement. There is no general usage in this regard.

EQUIPMENT IN APPARATUS.

It can not be insisted too strongly that the only profitable way to keep bees is in hives with movable frames. The bees build their combs in these frames, which can then be manipulated by the bee keeper as necessary. The keeping of bees in boxes, hollow logs, or straw "skeps" is not profitable, is often a menace to progressive bee keepers, and should be strongly condemned. Bees in box hives (plain boxes with no frames and with combs built at the will of the bees) are too often seen in all parts of the country. The owners may obtain from them a few pounds of inferior honey a year and carelessly continue in the antiquated practice. In some cases this type of beekeeping does little harm to others, but where diseases of the brood are present the box hive is a serious nuisance and should be abolished.

WORKSHOP.

It is desirable to have a workshop in the apiary where the crop may be cared for and supplies may be prepared. If the ground on which the hives are located is not level, it is usually better to have the shop on the lower side so that the heavier loads will be carried down grade. The windows and doors should be screened to prevent the entrance of bees. The wire cloth should be placed on the outside of the window frames and should be extended about 6 inches above the opening. This upper border should be held away from the frame with narrow wooden strips one-fourth inch in thickness so as to provide exits for bees which accidentally get into the house. Bees do not enter at such openings, and any bees which are carried into the house fly at once to the windows and then crawl upward, soon clearing the house of all bees. The windows should be so arranged that the glass may be slid entirely away from the openings to prevent bees from being imprisoned. The equipment of benches and racks for tools and supplies can be arranged as is best suited to the house. It is a good plan to provide racks for surplus combs, the combs being hung from strips separated the distance of the inside length of the hive.

HIVES.

It is not the purpose of this bulletin to advocate the use of any particular make of hive or other apparatus. Some general statements may be made, however, which may help the beginner in his choice.

The type of hive most generally used in this country (fig. 2) was invented by Langstroth in 1851. It consists of a plain wooden box holding frames hung from a rabbet at the top and not touching the sides, top, or bottom. Hives of this type are made to hold eight, ten, or more frames. The size of frame in general use, known as the

Langstroth (or L) frame ($9\frac{1}{8}$ by $17\frac{5}{8}$ inches), is more widely used than all others combined. One of the best features in hive manufacture developed by Langstroth is the making of the spaces between frames, side walls, and supers accurately, so that there is just room for the easy passage of bees. In a space of this size (called a "bee space") bees rarely build comb or deposit propolis. The number of frames used depends on the kind of honey produced (whether comb or extracted) and on the length of honey flow and other local factors. There are other hives used which have points of superiority. These will be found discussed in the various books on beekeeping and in the catalogues of dealers in bee keepers' supplies.

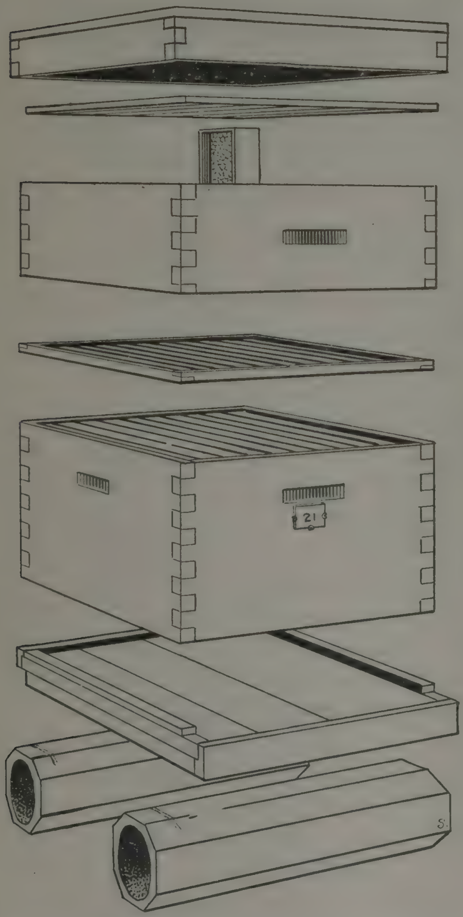

FIG. 2.—A 10-frame hive with comb-honey super and perforated zinc queen excluder.

Whatever hive is chosen, there are certain important points which should be insisted on. The material should be of the best; the parts must be accurately made, so that all frames or hives in the apiary are interchangeable. All hives should be of the same style and size; they should be as simple as it is possible to make them, to facilitate operation. Simple frames diminish the amount of propolis, which will interfere with manipulation. As a rule, it is better to buy hives and frames from a manufacturer of such goods rather than to try to make them, unless one is an expert woodworker.

The choice of a hive, while important, is usually given undue prominence in books on bees. In actual practice experienced bee keepers with different sizes and makes of hives under similar conditions do not find as much difference in their honey crop as one would be led to believe from the various published accounts.

Hives should be painted to protect them from the weather. It is usually desirable to use white paint to prevent excessive heat in the colony during hot weather. Other light colors are satisfactory, but it is best to avoid red or black.

HIVE STANDS.

Generally it is best to have each hive on a separate stand. The entrance should be lower than any other part of the hive. Stands of wood, bricks, tile (fig. 2), concrete blocks, or any other convenient material will answer the purpose. The hive should be raised above the ground, so that the bottom will not rot. It is usually not necessary to raise the hive more than a few inches. Where ants are a nuisance special hive stands are sometimes necessary.

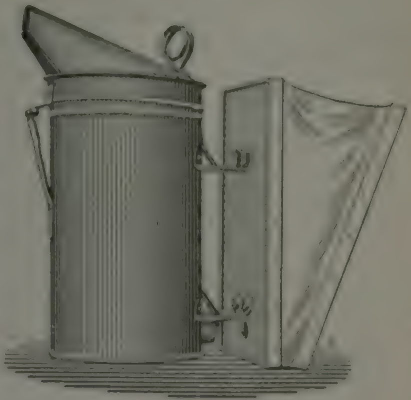

FIG. 3.—Smoker.

OTHER APPARATUS.

In addition to the hives in which the bees are kept some other apparatus is necessary. A good smoker to quiet the bees (fig. 3), consisting of a tin or copper receptacle to hold burning rotten wood or other material, with a bellows attached, is indispensable. A veil of black material, preferably with a black silk-tulle front (fig. 4), should be used. Black wire-cloth veils are also excellent. Even if a veil is not always used, it is desirable to have one at hand in case the bees become cross. Cloth or leather gloves are sometimes used to protect the hands, but they hinder most manipulations. Some sort of tool (fig. 5) to pry hive covers loose and frames apart is desirable. A screwdriver will answer, but any of the tools made especially for that purpose is perhaps better. Division boards

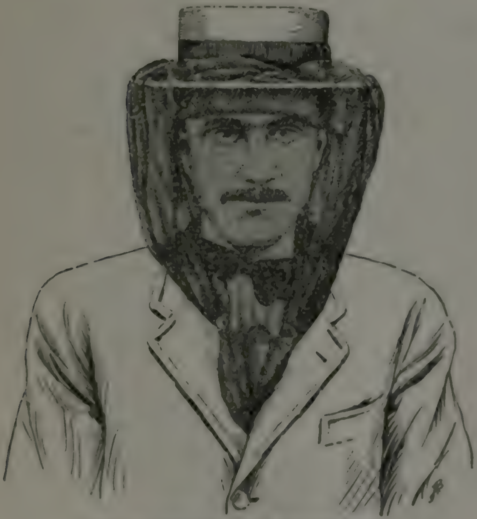

FIG. 4.—Bee veil with silk-tulle front.

drone traps (fig. 6), bee escapes (figs. 7 and 8), feeders (figs. 17, 18, 19, 20), foundation fasteners, wax extractors, bee brushes (fig. 9), queen-rearing outfits, and apparatus for producing comb or extracted honey (figs. 2, 21, 22) will be found described in catalogues of supplies; a full discussion of these implements would require too much space in this bulletin. A few of these things are illustrated, and their use will be evident to the bee keeper. It is best to have the frames filled with foundation to insure straight combs composed of worker cells only. Foundation is made from thin sheets of pure beeswax on which are impressed the bases of the cells of the comb. On this as a guide the worker bees construct the combs. When sheets of foundation are inserted they should be supported by wires stretched across the frames. Frames purchased from supply dealers are usually pierced for wiring. It should be remembered that manipulation based on a knowledge of bee behavior is of far greater importance than any particular style of apparatus. In a short discussion like the present it is best to omit descriptions of appliances, since supply dealers will be glad to furnish whatever information is desired concerning apparatus.

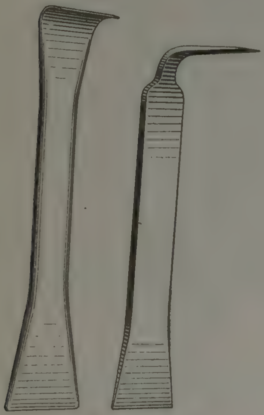
Fig. 5.—Hive tools.

EQUIPMENT IN BEES.

As stated previously, it is desirable to begin beekeeping with a small number of colonies. In purchasing these it is usually best to obtain them near at home rather than to send to a distance, for there is considerable liability of loss in shipment. Whenever possible it is better to get bees already domiciled in the particular hive chosen by the bee keeper, but if this is not practicable then bees in any hives or in box hives may be purchased and transferred. It is a matter of small importance what race of bees is purchased, for queens of any race may be obtained and introduced in place of the original queen, and in a short time the workers will all be of the same

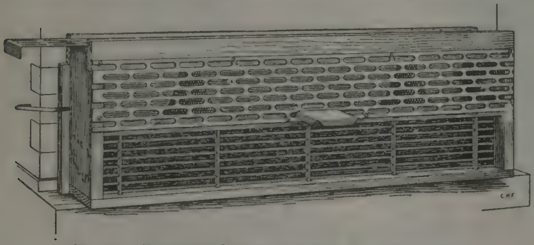
Fig. 6.—Drone and queen trap on hive entrance.

race as the introduced queen. This is due to the fact that during the honey season worker bees die rapidly, and after requeening they are replaced by the offspring of the new queen.

A most important consideration in purchasing colonies of bees is to see to it that they are free from disease. In many States and counties there are inspectors of apiaries who can be consulted on this point, but if this is not possible even a novice can tell whether or not there is anything wrong with the brood, and it is always safest to refuse hives containing dead brood.

The best time of the year to begin beekeeping is in the spring, for during the first few months of ownership the bee keeper can study the subject and learn what to do, so that he is not so likely to make a mistake which will end in loss of bees. It is usually best to buy good strong colonies with plenty of brood for that season of the year, but if this is not practicable, then smaller colonies, or nuclei, may be purchased and built up during the summer season. Of course, no surplus honey can be expected if all the honey gathered goes into the making of additional bees. It is desirable to get as little drone comb as possible and a good supply of honey in the colonies purchased.

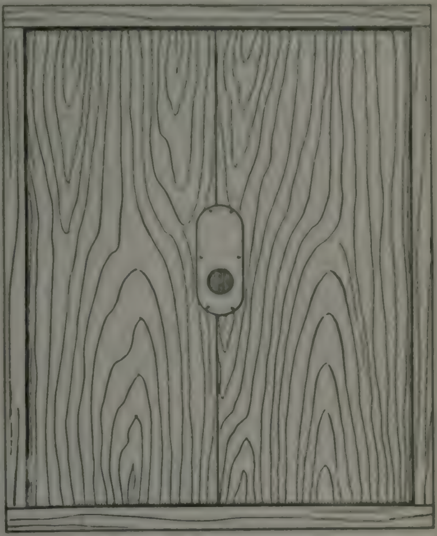

FIG. 7.—Bee escape for removing bees from supers.

The question as to what race and strain of bees is to be kept is important. If poor stock has been purchased locally, the bee keeper should send to some reliable queen breeder for good queens as a foundation for his apiary. Queens may be purchased for $1 each for "untested" to several dollars each for "selected" breeding queens. Usually it will not pay beginners to buy "selected" breeding queens, for they are not yet prepared to make the best use of such stock. "Untested" or "tested" queens are usually as good a quality as are profitable for a year or so, and there is also less danger in mailing "untested" (young) queens.

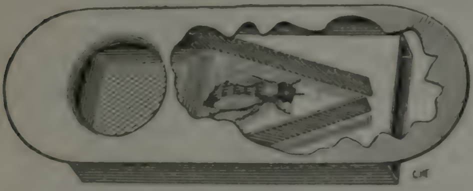

FIG. 8.—Spring bee escape.

Various races of bees have been imported into the United States and among experienced bee keepers there are ardent advocates of almost all of them. The black or German race was the first imported, very early in the history of the country, and is found everywhere, but usually not entirely pure. As a rule this race is not desirable. No attention has been paid to breeding it for improvement in this country, and it is usually found in the hands of careless bee keepers. As a result it is inferior, although it often produces beautiful comb honey.

The Italian bees, the next introduced, are the most popular race among the best bee keepers in this country, and with good reason. They are vigorous workers and good honey gatherers, defend their hives well, and above all have been more carefully selected by American breeders than any other race. Especially for the last reason it is usually desirable to keep this race. That almost any other race of bees known could be bred to as high a point as the Italians, and perhaps higher, can not be doubted, but the bee keeper now gets the benefit of what has been done for this race. It should not be understood from this that the efforts at breeding have been highly successful. On the contrary, bee breeding will compare very unfavorably with the improvement of other animals or plants which have been the subject of breeding investigations.

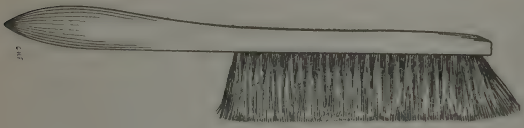

FIG. 9.—Bee brush.

Italian bees have been carefully selected for color by some breeders to increase the area of yellow on the abdomen, until we now have what are known as "five-banded" bees. These are very beautiful, but it can scarcely be claimed that they are improved as honey producers or in regard to gentleness. They are kept mostly by amateurs.

Some breeders have claimed to select Italians for greater length of tongue, with the object of getting a bee which could obtain the abundance of nectar from red clover. If any gain is ever made in this respect, it is soon lost. The terms "red-clover bees" or "long-tongued bees" are somewhat misleading, but are ordinarily used as indicating good honey producers.

Caucasian bees, formerly distributed throughout the country by this department, are the most gentle race of bees known. They are not stingless, however, as is often stated in newspapers and other periodicals. Many report them as good honey gatherers. They are more prolific than Italians and may possibly become popular. Their worst characteristic is that they gather great quantities of propolis and build burr and brace combs very freely. They are most desirable bees for the amateur or for experimental purposes.

Carniolan and Banat bees have some advocates, and are desirable in that they are gentle. Little is known of Banats in this country. Carniolans swarm excessively unless in large hives. Cyprians were formerly used somewhat, but are now rarely found pure, and are undesirable either pure or in crosses because of the fact that they sting with the least provocation and are not manageable with smoke. They are good honey gatherers, but their undesirable qualities have caused them to be discarded by American bee keepers. "Holy-land," Egyptian, and Punic (Tunisian) bees have also been tried and have been universally abandoned.

The Department of Agriculture does not now distribute or sell queen bees or colonies of bees of any race.

BEE BEHAVIOR.

The successful manipulation of bees depends entirely on a knowledge of their habits. This is not generally recognized, and most of the literature on practical beekeeping consists of sets of rules to guide manipulations. This is too true of the present paper, but is due to a desire to make the bulletin short and concise. While this method usually answers, it is nevertheless faulty, in that, without a knowledge of fundamental principles of behavior, the bee keeper is unable to recognize the seemingly abnormal phases of activity, and does not know what to do under such circumstances. Rules must, of course, be based on the usual behavior. By years of association the bee keeper almost unconsciously acquires a wide knowledge of bee behavior, and consequently is better able to solve the problems which constantly arise. However, it would save an infinite number of mistakes and would add greatly to the interest of the work if more time were expended on a study of behavior; then the knowledge gained could be applied to practical manipulation.

A colony of bees consists normally of one queen bee (fig. 10, *b*), the mother of the colony, and thousands of sexually undeveloped females called workers (fig. 10, *a*), which normally lay no eggs, but build the comb, gather the stores, keep the hive clean, feed the young, and do the other work of the hive. During part of the year there are also present some hundreds of males (fig. 10, *c*) or drones (often removed or restricted in numbers by the bee keeper), whose only service is to mate with young queens. These three types are easily recognized, even by a novice. In nature the colony lives in a hollow tree or other cavity, but under manipulation thrives in the artificial hives provided. The combs which form their abode are composed of wax secreted by the workers. The hexagonal cells of the two vertical layers constituting each comb have interplaced ends on a common septum. In the cells of these combs are reared the developing bees, and honey and pollen for food are also stored here.

The cells built naturally are not all of the same size, those used in rearing worker bees being about one-fifth of an inch across, and those used in rearing drones and in storing honey about one-fourth of an inch across (fig. 11). The upper cells in natural combs are more irregular, and generally curve upward at the outer end. They are used chiefly for the storage of honey. Under manipulation the size of the cells is controlled by the bee keeper by the use of comb foundation—sheets of pure beeswax on which are impressed the bases of cells and on which the bees build the side walls.

In the North, when the activity of the spring begins, the normal colony consists of the queen and some thousands of workers. As the outside temperature raises, the queen begins to lay eggs (fig. 12, *a*) in the worker cells. These in time develop into white larvæ (fig. 12, *b*, *c*), which grow to fill the cells. They are then capped over and transform first into pupæ (fig. 12, *d*) and then into adult worker bees. As the weather grows warmer, and the colony increases in size by the emergence of the young bees, the quantity of brood is increased. The workers continue to bring in pollen, nectar to be made into honey, and water for brood rearing. When the hive is nearly filled with bees and stores, or when a heavy honey flow is on, the queen begins to lay eggs in the larger cells, and these develop into drones or males.

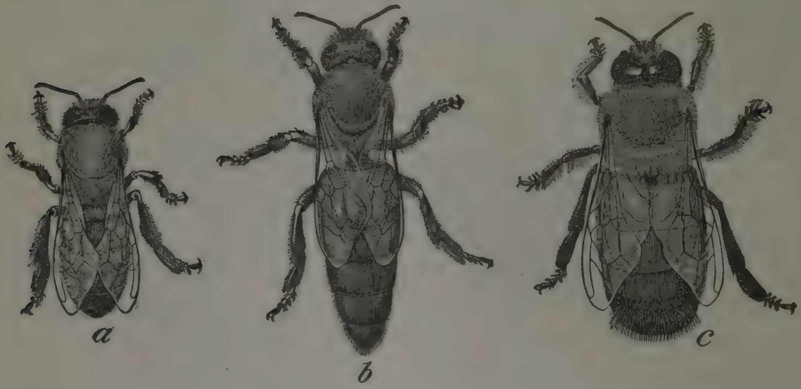

Fig. 10.—The honey bee: *a*, Worker; *b*, queen; *c*, drone. Twice natural size.

Continued increase of the colony would result in the formation of enormous colonies, and unless some division takes place no increase in the number of colonies will result. Finally, however, the workers begin to build queen cells (fig. 13). These are larger than any other cells in the hive and hang on the comb vertically. In size and shape they may be likened to a peanut, and are also rough on the outside.

In preparing for swarming the queen sometimes lays eggs in partly constructed queen cells, but when a colony becomes queenless the cells are built around female larvæ. The larvæ in these cells receive special food, and when they have grown to full size they, too, are sealed up, and the colony is then ready for swarming.

The issuing of the first swarm from a colony consists of the departure of the original queen with part of the workers. They leave behind the honey stores, except such as they can carry in their honey stomachs, the brood, some workers, drones, several queen cells, from which will later emerge young queens, but no adult queen. By this interesting process the original colony is divided into two.

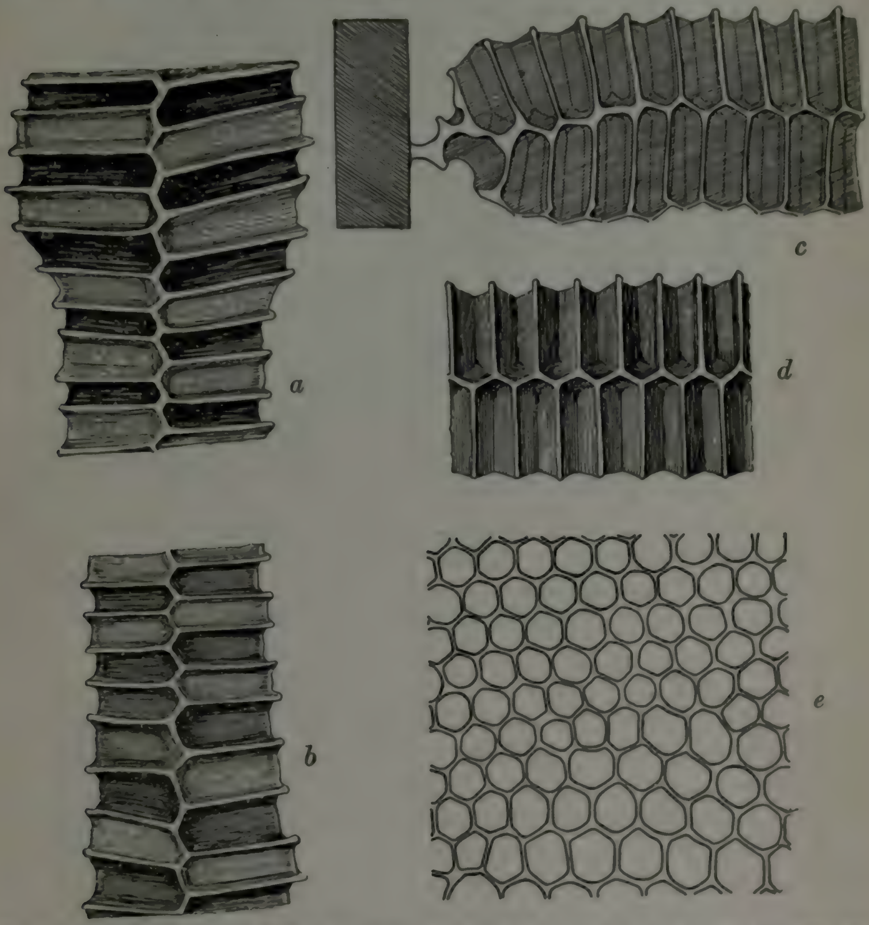

Fig. 11.—Comb architecture: *a*, Vertical section at top of comb; *b*, vertical section showing transition from worker to drone cells; *c*, horizontal section at side of comb showing end bar of frame; *d*, horizontal section of worker brood cells; *e*, diagram showing transition cells. Natural size.

The swarm finds a new location in some place, such as a hollow tree, or, if cared for by the bee keeper, in a hive. The workers build new combs, the queen begins laying, and in a short time the swarm becomes a normal colony.

The colony on the old stand (parent colony) is increased by the bees emerging from the brood. After a time (usually about seven or eight days) the queens in their cells are ready to emerge. If the colony is only moderately strong the first queen to emerge is allowed by the workers to tear down the other queen cells and kill the queens not yet emerged, but if a "second swarm" is to be given off the queen cells are protected.

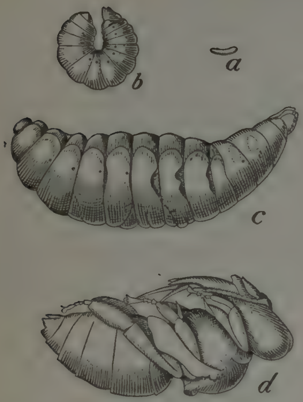

Fig. 12.—The honey bee: *a*, Egg; *b*, young larva; *c*, old larva; *d*, pupa. Three times natural size.

If the weather permits, when from 5 to 8 days old, the young queen flies from the hive to mate with a drone. Mating usually occurs but once during the life of the queen and always takes place on the wing. In mating she receives enough spermatozoa (male sex cells) to last throughout her life. She returns to the hive after mating, and in about two days begins egg laying. The queen never leaves the hive except at mating time or with a swarm, and her sole duty in the colony is to lay eggs to keep up the population.

When the flowers which furnish most nectar are in bloom, the bees usually gather more honey than they need for their own use, and this the bee keeper can safely remove. They continue the collection of honey and other activities until cold weather comes on in the fall, when brood rearing ceases; they then become relatively quiet, remaining in the hive all winter, except for short flights on warm days. When the main honey flow is over, the drones are usually driven from the hive. By that time the virgin queens have been mated and drones are of no further use. They are not usually stung to death, but are merely carried or driven from the hive by the workers and starve. A colony of bees which for any reason is without a queen does not expel the drones.

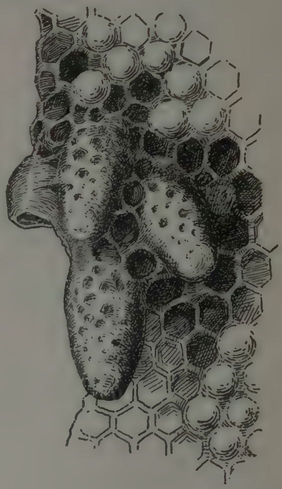

Fig. 13.—Queen cells. Natural size.

Many abnormal conditions may arise in the activity of a colony, and it is therefore necessary for the bee keeper to understand most of these, so that when they occur he may overcome them. If a virgin queen is prevented from mating she generally dies, but occasionally begins to lay eggs after about four weeks. In this event, however, all of the eggs which develop become males. Such a queen is commonly called a "drone layer."

If the virgin queen is lost while on her flight, or the colony at any other time is left queenless without means of rearing additional queens, it sometimes happens that some of the workers begin to lay eggs. These eggs also develop only into drones.

It also happens at times that when a queen becomes old her supply of spermatozoa is exhausted, at which time her eggs also develop only into drones. These facts are the basis of the theory that the drone of the bee is developed from an unfertilized egg or is parthenogenetic. A full discussion of this point is impossible in this place.

The work of the hive is very nicely apportioned among the inmates, so that there is little lost effort. As has been stated, the rearing of young is accomplished by having one individual to lay eggs and numerous others (immature females or workers) to care for the larvæ. In like manner all work of the colony is apportioned. In general, it may be stated that all inside work—wax building, care of brood, and cleaning—is done by the younger workers, those less than 17 days old, while the outside work of collecting pollen and nectar to be made into honey is done by the older workers. This plan may be changed by special conditions. For example, if the colony has been queenless for a time and a queen is then given, old workers may begin the inside work of feeding larvæ, and these may also secrete wax. Or, if the old workers are all removed, the younger bees may begin outside work. As a rule, however, the general plan of division of labor according to age is probably followed rather closely.

DIRECTIONS FOR GENERAL MANIPULATIONS.

Bees should be handled so that they will be little disturbed in their work. As much as possible, stings should be avoided during manipulation. This is true, not so much because they are painful to the operator, but because the odor of poison which gets into the air irritates the other bees and makes them more difficult to manage. For this reason it is most advisable to wear a black veil (fig. 4) over a wide-brimmed hat and to have a good smoker (fig. 3). Gloves, however, are usually more an inconvenience than otherwise. Gauntlets or rubber bands around the cuffs keep the bees from crawling up the sleeve. It is best to avoid black clothing, since that color seems to excite bees; a black felt hat is especially to be avoided.

Superfluous quick movements tend to irritate the bees. The hive should not be jarred or disturbed any more than necessary. Rapid movements are objectionable, because with their peculiar eye structure bees probably perceive motion more readily than they do objects. Persons not accustomed to bees, on approaching a hive, often strike at bees which fly toward them or make some quick movement of the head or hand to avoid the sting which they fear is to follow. This should not be done, for the rapid movement, even if not toward the bee, is far more likely to be followed by a sting than remaining quiet.

The best time to handle bees is during the middle of warm days, particularly during a honey flow. Never handle bees at night or on cold, wet days unless absolutely necessary. The work of a beginner may be made much easier and more pleasant by keeping gentle bees. Caucasians, Carniolans, Banats, and some strains of Italians ordinarily do not sting much unless unusually provoked or except in bad weather. Common black bees or crosses of blacks with other races are more irritable. It may be well worth while for the beginner to procure gentle bees while gaining experience in manipulation. Later on, this is less important, for the bee keeper learns to handle bees with little inconvenience to himself or to the bees. Various remedies for bee stings have been advocated, but they are all useless. The puncture made by the sting is so small that it closes when the sting is removed and liquids can not be expected to enter. The best thing to do when stung is to remove the sting as soon as possible without squeezing the poison sac, which is usually attached. This can be done by scraping it out with a knife or finger nail. After this is done the injured spot should be let alone and not rubbed with any liniment. The intense itching will soon disappear; any irritation only serves to increase the afterswelling.

Before opening a hive the smoker should be lighted and the veil put on. A few puffs of smoke directed into the entrance will cause the bees to fill themselves with honey and will drive back the guards. The hive cover should be raised gently, if necessary being pried loose with a screwdriver or special hive tool. When slightly raised, a little more smoke should be blown in vigorously on the tops of the frames, or if a mat covering for the frames is used, the cover should be entirely removed and one corner of the mat lifted to admit smoke. It is not desirable to use any more smoke than just enough to subdue the bees and keep them down on the frames. If at any time during manipulation they become excited, more smoke may be necessary. Do not stand in front of the entrance, but at one side or the back.

After the frames are exposed they may be loosened by prying gently with the hive tool and crowded together a little so as to give room for the removal of one frame. In cool weather the propolis (bee glue) may be brittle. Care should be exercised not to loosen this propolis with a jar. The first frame removed can be leaned against the hive, so that there will be more room inside for handling the others. During all manipulations bees must not be mashed or crowded, for it irritates the colony greatly and may make it necessary to discontinue operations. Undue crowding may also crush the queen. If bees crawl on the hands, they may be gently brushed off or thrown off.

In examining a frame hold it over the hive if possible, so that any bees or queen which fall may drop into it. Freshly gathered honey also often drops from the frame, and if it falls in the hive the bees can quickly clean it up, whereas if it drops outside it is untidy and may cause robbing. If a frame is temporarily leaned against the hive, it should be placed in a nearly upright position to prevent breakage and leaking of honey. The frame on which the queen is located should not be placed on the ground, for fear she may crawl away and be lost. It is best to lean the frame on the side of the hive away from the operator, so that bees will not crawl up his legs.

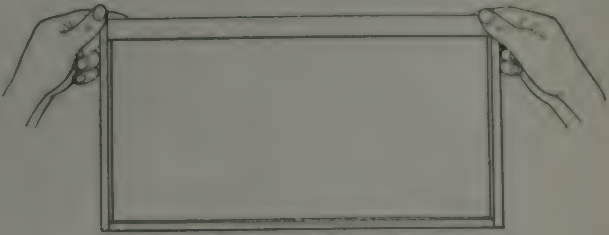

FIG. 14.—Handling the frame: First position.

In handling frames the comb should always be held in a vertical position, especially if it contains much honey. When a frame is lifted from the hive by the top bar, the comb is vertical with one side toward the operator (fig. 14). To examine the reverse side, raise one end of the top bar until it is perpendicular (fig. 15), turn the frame on the top bar as an axis until the reverse side is in view, and then lower to a horizontal position with the top bar below (fig. 16). In this way there is no extra strain on the comb and the bees are not irritated. This care is not so necessary with wired combs, but it is a good habit to form in handling frames.

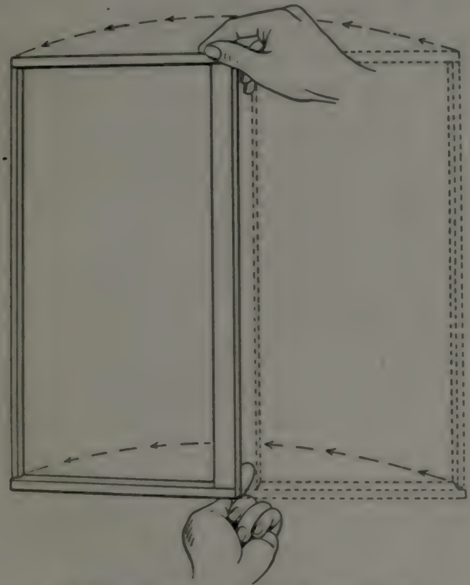

FIG. 15.—Handling the frame: Second position.

It is desirable to have combs composed entirely of worker cells in order to reduce the amount of drone brood. The use of full sheets of foundation will bring this about and is also of value in making the combs straight, so that bees are not mashed in removing the frame. It is extremely difficult to remove combs built crosswise in the hive, and this should never be allowed to occur. Such a hive is even worse than a plain box hive. Superfluous inside fixtures should be avoided, as they tend only to impede manipulation. The hive should also be placed so that the entrance is perfectly horizontal and a little lower than the back of the hive. The frames will then hang in a vertical position, and the outer ones will not be fastened by the bees to the hive body if properly spaced at the top.

In placing frames in the hive great care should be exercised that they are properly spaced. Some frames are self-spacing, having projections on the side, so that when placed as close as possible they are the correct distance apart. These are good for beginners or persons who do not judge distances well and are preferred by many professional bee keepers. If unspaced frames are used, the brood frames should be $1\frac{3}{8}$ inches from center to center. A little practice will usually enable anyone to space quickly and accurately. Careful spacing is necessary to prevent the building of combs of irregular thickness and to retard the building of pieces of comb from one frame to another.

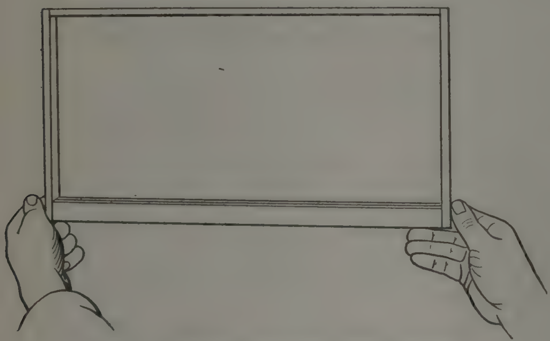

FIG. 16.—Handling the frame: Third position.

A beginner in beekeeping should by all means, if possible, visit some experienced bee keeper to get suggestions in handling bees. More can be learned in a short visit than in a considerably longer time in reading directions, and numerous short cuts which are acquired by experience will well repay the trouble or expense of such a visit. Not all professional bee keepers manipulate in the very best way, but later personal experience will correct any erroneous information. Above all, personal experimentation and a study of bee activity are absolute necessities in the practical handling of bees.

TRANSFERRING.

In increasing the apiary it is sometimes best to buy colonies in box hives on account of their smaller cost and to transfer them to hives with movable frames. This should be done as soon as possible, for box-hive colonies are of small value as producers. The best time to transfer is in the spring (during fruit bloom in the North) when the amount of honey and the population of the colony are at a minimum.

Transferring should not be delayed until spring merely because that season is best for the work. It may be done at any time during the active season, but, whenever possible, during a honey flow, to prevent robbing. If necessary, it may be done in a tent such as is often used in manipulating colonies. By choosing a time of the day when the largest number of bees are in the field the work will be lessened.

Plan 1.—The box hive should be moved a few feet from its stand and in its place should be put a hive with movable frames containing full sheets of foundation. The box hive should be turned upside down and a small, empty box inverted over it. By drumming continuously on the box hive with sticks for a considerable time the bees will be made to desert their combs and go to the upper box, and when most of them are clustered above, the bees may be dumped in front of the entrance of the hive which is to house them. The queen will usually be seen as the bees enter the hive, but, in case she has not left the old combs, more drumming will induce her to do so. It is necessary that the queen be in the hive before this manipulation is finished. The old box hive containing brood may now be placed right side up in a new location and in 21 days all of the worker brood will have emerged and probably some new queens will have been reared. These bees may then be drummed out and united with their former hive mates by vigorously smoking the colony and the drummed bees and allowing the latter to enter the hive through a perforated zinc to keep out the young queens. The comb in the box hive may then be melted up and any honey which it may contain used as the bee keeper sees fit. By this method good straight combs are obtained. If little honey is being gathered, the colony in the hive must be provided with food.

Plan 2.—If, on the other hand, the operator desires to save the combs of the box hive, the bees may be drummed into a box and the brood combs and other fairly good combs cut to fit frames and tied in place or held with rubber bands, strings, or strips of wood until the bees can repair the damage and fill up the breaks. These frames can then be hung in a hive on the old stand and the bees allowed to go in. The cutting of combs containing brood with more or less bees on them is a disagreeable job, and, since the combs so obtained are usually of little value in an apiary, the first method is recommended.

Plan 3.—Another good plan is to wait until the colony swarms and then move the box hive to one side. A movable frame hive is now placed in the former location of the box hive and the swarm is hived in it. In this way all returning field bees are forced to join the swarm. In 21 days all of the worker brood in the box hive will have emerged. These young bees may then be united with the bees in the frame hive and the box hive destroyed.

Colonies often take up their abode in walls of houses and it is often necessary to remove them to prevent damage from melting combs. If the cavity in which the combs are built can be reached, the method of procedure is like that of transferring, except that drumming is impractical and the bees must simply be subdued with smoke and the combs cut out with the bees on them.

Another method which is often better is to place a bee escape over the entrance to the cavity, so that the bees can come out, but can not return. A cone of wire cloth about 8 inches high with a hole at the apex just large enough for one bee to pass will serve as a bee escape, or regular bee escapes (fig. 8) such as are sold by dealers may be used. A hive which they can enter is then placed beside the entrance. The queen is not obtained in this way and, of course, goes right on laying eggs, but as the colony is rapidly reduced in size the amount of brood decreases. As brood emerges, the younger bees leave the cavity and join the bees in the hive, until finally the queen is left practically alone. A new queen should be given to the bees in the hive as soon as possible, and in a short time they are fully established in their new quarters. After about four weeks, when all or nearly all of the brood in the cavity has emerged, the bee escape should be removed and as large a hole made at the entrance of the cavity as possible. The bees will then go in and rob out the honey and carry it to the hive, leaving only empty combs. The empty combs will probably do no damage, as moths usually soon destroy them and they may be left in the cavity and the old entrance carefully closed to prevent another swarm from taking up quarters there.

In transferring bees from a hollow tree the method will depend on the accessibility of the cavity. Usually it is difficult to drum out the bees and the combs can be cut out after subduing the colony with smoke.

UNITING.

Frequently colonies become queenless when it is not practicable to give them a new queen, and the best practice under such conditions is to unite the queenless bees to a normal colony. If any colonies are weak in the fall, even if they have a queen, safe wintering is better insured if two or more weak colonies are united, keeping the best queen. Under various other conditions which may arise the bee keeper may find it desirable to unite bees from different colonies. Some fundamental facts in bee behavior must be thoroughly understood to make this a success.

Every colony of bees has a distinctive colony odor and by this means bees recognize the entering of their hive by bees from other colonies and usually resent it. If, however, a bee comes heavily laden from the field and flies directly into the wrong hive without hesitation it is rarely molested. In uniting colonies, the separate colony odors must be hidden, and this is done by smoking each colony vigorously. It may at times be desirable to use tobacco smoke, which not only covers the colony odor but stupefies the bees somewhat. Care should be taken not to use too much tobacco, as it will completely overcome the bees. The queen to be saved should be caged for a day or two to prevent the strange bees from killing her in the first excitement.

Another fact which must be considered is that the bees of a colony carefully mark the location of their own hive and remember that location for some time after they are removed. If, therefore, two colonies in the apiary which are not close together are to be united, they should be moved gradually nearer, not more than a foot at a time, until they are side by side, so that the bees will not return to their original locations and be lost. As the hives are moved gradually the slight changes are noted and no such loss occurs. As a further precaution, a board should be placed in front of the entrance in a slanting position, or brush and weeds may be thrown down so that when the bees fly out they recognize the fact that there has been a change and accustom themselves to the new place. If uniting can be done during a honey flow, there is less danger of loss of bees by fighting, or if done in cool weather, when the bees are not actively rearing brood, the colony odors are diminished and the danger is reduced.

It is an easy matter to unite two or more weak swarms to make one strong one, for during swarming the bees have lost their memory of the old location, are full of honey, and are easily placed wherever the bee keeper wishes. They may simply be thrown together in front of a hive. Swarms may also be given to a newly established colony with little difficulty.

PREVENTING ROBBING IN THE APIARY.

When there is no honey flow bees are inclined to rob other colonies, and every precaution must be taken to prevent this. Feeding often attracts other bees, and, if there are indications of robbing, the sirup or honey should be given late in the day. As soon as robbing begins, manipulation of colonies should be discontinued, the hives closed, and, if necessary, the entrances contracted as far as the weather will permit. If brush is thrown in front of the entrance, robbers are less likely to attempt entering. At all times honey which has been removed from the hives should be kept where no bees can get at it, so as not to incite robbing.

FEEDING.

During spring manipulations, in preparing bees for winter, and at other times it may be necessary to feed bees for stimulation or to provide stores. *Honey from an unknown source should never be used,* for fear of introducing disease, and sirup made of granulated sugar is cheapest and best for this purpose. The cheaper grades of sugar or molasses should never be used for winter stores. The proportion of sugar to water depends on the season and the purpose of the feeding. For stimulation a proportion of one-fourth to one-third sugar by volume is enough, and for fall feeding, especially if rather late, a solution containing as much sugar as it will hold when cold is best. There seems to be little advantage in boiling the sirup. Tartaric acid in small quantity may be added for the purpose of changing part of the cane sugar to invert sugar, thus retarding granulation. The medication of sirup as a preventive or cure of brood disease is often practiced, but it has not been shown that such a procedure is of any value. If honey is fed, it should be diluted somewhat, the amount of dilution depending on the season. If robbing is likely to occur, feeding should be done in the evening.

Numerous feeders are on the market, adapted for different purposes and methods of manipulation (figs. 17, 18, 19). A simple feeder can be made of a tin pan filled with excelsior or shavings (fig. 20). This is filled with sirup and placed on top of the frames in a super or hive body. It is advisable to lean pieces of wood on the pan as runways for the bees, and to attract them first to the sirup, either by mixing in a little honey or by spilling a little sirup over the frames and sticks.

It may be stated positively that it does not pay financially, or in any other way, to feed sugar sirup to be stored in sections and sold as comb honey. Of course, such things have been tried, but the consumption of sugar during the storing makes the cost greater than the value of pure floral honey.

SPRING MANAGEMENT.

The condition of a colony of bees in the early spring depends largely upon the care given the bees the preceding autumn and in the method of wintering. If the colony has wintered well and has a good prolific queen, preferably young, the chances are that it will become strong in time to store a good surplus when the honey flow comes.

The bees which come through the winter, reared the previous autumn, are old and incapable of much work. As the season opens they go out to collect the early nectar and pollen, and also care for the brood. The amount of brood is at first small, and as the new workers emerge they assist in the brood rearing so that the extent of the brood can be gradually increased until it reaches its maximum about the beginning of the summer. The old bees die off rapidly.

If brood rearing does not continue late in the fall, so that the colony goes into winter with a large percentage of young bees, the old bees may die off in the spring faster than they are replaced by emerging brood. This is known as "spring dwindling." A preventive remedy for this may be applied by feeding, if necessary, the autumn before, or keeping up brood rearing as late as possible by some other means.

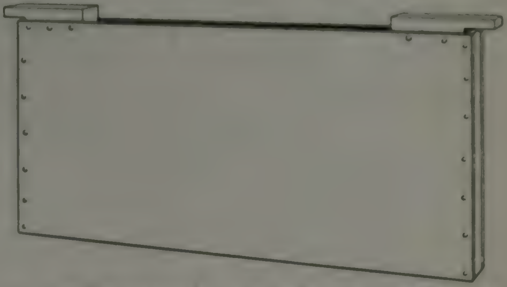
FIG. 17.—Division-board feeder to be hung in hive in place of frame.

If spring dwindling begins, however, it can be diminished somewhat by keeping the colony warm and by stimulative feeding, so that all the energy of the old bees may be put to the best advantage in rearing brood to replace those dying off. The size of the brood chamber can also be reduced to conserve heat.

It sometimes happens that when a hive is examined in the spring the hive body and combs are spotted with brownish yellow excrement. This is an evidence of what is commonly called "dysentery." The cause of this trouble is long-continued confinement with a poor quality of honey for food. Honeydew honey and some of the inferior floral honeys contain a relatively large percentage of material which bees can not digest, and, if they are not able to fly for some time, the intestines become clogged with fæcal matter and a diseased condition results. Worker bees never normally deposit their fæces in the hive. The obvious preventive for this is to provide the colony with good honey or sugar sirup the previous fall. "Dysentery" frequently entirely destroys colonies, but if the bees can pull through until warm days permit a cleansing flight they recover promptly.

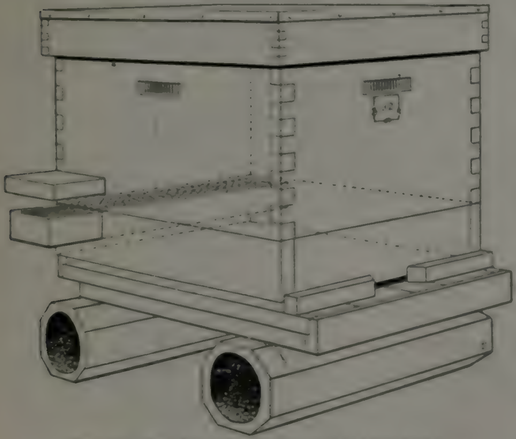
FIG. 18.—Feeder set in collar under hive body.

Bees should not be handled in the early spring any more than necessary, for to open a hive in cool weather wastes heat and may even kill the brood by chilling. The hive should be kept as warm as possible in early spring as an aid to brood rearing. It is a good practice to wrap hives in *black* tar paper in the spring, not only that it may aid in conserving the heat of the colony, but in holding the sun's heat rays as a help to the warmth of the hive. This wrapping should be put on as soon as an early examination has shown the colony to be in good condition, and there need be no hurry in taking it off. A black wrapping during the winter is not desirable, as it might induce brood rearing too early and waste the strength of the bees.

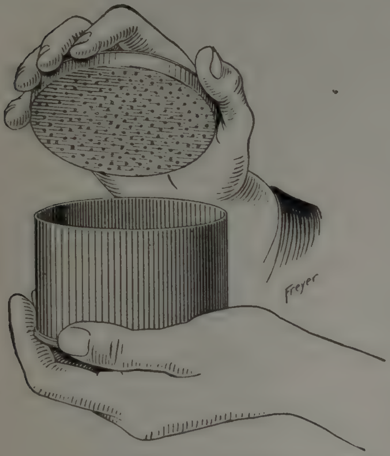

FIG. 19.—"Pepper-box" feeder for use on top of frames.

As a further stimulus to brood rearing, stimulative feeding of sugar sirup in early spring may be practiced. This produces much the same effect as a light honey flow does and the results are often good. Others prefer to give the bees such a large supply of stores in the fall that when spring comes they will have an abundance for brood rearing, and it will not be necessary to disturb them in cool weather. Both ideas are good, but judicious stimulative feeding usually more than pays for the labor. Colonies should be fed late in the day, so that the bees will not fly as a result of it, and so that robbing will not be started. When the weather is warmer and more settled the brood cluster may be artificially enlarged by spreading the frames so as to insert an empty comb in the middle. The bees will attempt to cover all the brood that they already had, and the queen will at once begin laying in the newly inserted comb, thus making a great increase in the brood. This practice is desirable when carefully done, but may lead to serious

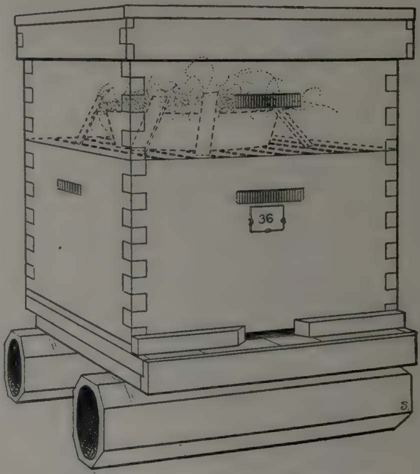

FIG. 20.—Pan in super arranged for feeding.

results if too much new brood is produced. A beginner had better leave the quantity of brood to the bees.

It is desirable early in the season, before any preparations are made for swarming, to go through the apiary and clip one wing of each queen (see p. 30). This should be done before the hive becomes too populous. It is perhaps best to clip queens as they are introduced, but some colonies may rear new ones without the knowledge of the owner, and a spring examination will insure no escaping swarms. The beginner should perhaps be warned not to clip the wings of a virgin queen.

Queens sometimes die during the winter and early spring, and since there is no brood from which the bees can replace them, the queenless colonies are "hopelessly queenless." Such colonies are usually restless and are not active in pollen gathering. If, on opening a colony, it is found to be without a queen and reduced in numbers, it should be united with another colony by smoking both vigorously and caging the queen in the queen-right colony for a day or two to prevent her being killed. A frame or two of brood may be added to a queenless colony, not only to increase its strength, but to provide young brood from which they can rear a queen. Bee keepers in the North can frequently buy queens from southern breeders early in the spring and naturally this is better than leaving the colony without a queen until the bees can rear one, as it is important that there be no stoppage in brood rearing at this season.

SWARM MANAGEMENT AND INCREASE.

The excessive rearing of brood at the wrong season or increase in the number of colonies greatly reduces the surplus honey crop by consumption. The ideal to which all progressive bee keepers work, when operating simply for honey, is to stimulate brood rearing to prepare bees for gathering, to retard breeding when it is less desirable, and to prevent swarming. Formerly the measure of success in beekeeping was the amount of increase by swarming, but this is now recognized as being quite the contrary of success.

The stimulation of brood rearing in the spring, however, makes it more likely that swarming will occur; so that the operator must counteract the tendency to swarm. This is especially true in comb-honey production. Very few succeed in entirely preventing swarming, but by various methods the situation can be largely controlled.

When a swarm issues, it usually first settles on a limb of a tree or bush near the apiary. It was formerly common to make a noise by beating pans or ringing bells in the belief that this causes the swarm to settle. There is no foundation for such action on the part of the bee keeper. If the bees alight on a small limb that can be spared it may simply be sawed off and the bees carried to the hive and thrown on a sheet or hive cover in front of the entrance. If the limb can not be cut, the swarm can be shaken off into a box or basket on a pole and hived. If the bees light on the trunk of a tree or in some inaccessible place they can first be attracted away by a comb, preferably containing unsealed brood. In these manipulations it is not necessary to get all the bees, but if the queen is not with those which are put into the hive the bees will go into the air again and join the cluster.

If a queen is clipped as recommended under "Spring management" (p. 29) the swarm will issue just the same, but the queen, not being able to fly, will simply wander about on the ground in front of the hive, where she can be caught and caged. The parent colony can then be removed to a new stand and a new hive put in its place. The bees will soon return and the queen can be freed among them as they enter. The field bees on returning will enter the new hive with the swarm, thus decreasing still more the parent colony and making a second swarm less probable. To make sure of this, however, all queen cells except one good one can be removed soon after the swarm issues. Another method of preventing second swarms is to set the old hive beside the swarm and in a week move the old hive to another place. The field bees of the parent colony then join the swarm and the parent colony is so much reduced that a second swarm does not issue.

To hold a swarm it is desirable to put one frame containing healthy unsealed brood in the new hive. The other frames may contain full sheets or starters of foundation. Usually comb-honey supers or surplus bodies for extracting frames will have been put on before swarming occurs. These are given to the swarm on the old stand and separated from the brood chamber by queen-excluding perforated zinc. In three or four days the perforated zinc may be removed if desired.

When clipping the queen's wing is not practiced, swarms may be prevented from leaving by the use of queen traps of perforated zinc (fig. 6). These allow the workers to pass out, but not drones or queens, which, on leaving the entrance, pass up to an upper compartment from which they can not return. These are also used for keeping undesirable drones from escaping, and the drones die of starvation. When a swarm issues from a hive provided with a queen trap the queen goes to the upper compartment and remains there until released by the bee keeper. The workers soon return to the hive. When the operator discovers the queen outside, the colony may be artificially swarmed to prevent another attempt at natural swarming. A queen trap should not be kept on the hive all the time for fear the old queen may be superseded and the young queen prevented from flying out to mate.

ARTIFICIAL SWARMING

If increase is desired, it is better to practice some method of artificial swarming and to forestall natural swarming rather than be compelled to await the whims of the colonies. The situation should be under the control of the bee keeper as much as possible. The bees, combs, and brood may be divided into two nearly equal parts and a queen provided for the queenless portion; or small colonies, called nuclei, may be made from the parent colony, so reducing its strength that swarming is not attempted. These plans are not as satisfactory as shaken swarms, since divided colonies lack the vigor of swarms.

A good method of artificially swarming a colony is to shake most of the bees from the combs into another hive on the old stand with starters (narrow strips) of foundation. The hive containing the brood with some bees still adhering is then moved to a new location. If receptacles for surplus honey have been put on previously, as they generally should be, they should now be put over the artificial swarm separated from the brood compartment by perforated zinc.

This method of artificially swarming (usually called by bee keepers "shook" swarming) should not be practiced too early, since natural swarming may take place later. The colony should first have begun its preparations for swarming. The method is particularly useful in comb-honey production. The bees may be prevented from leaving the hive by the use of a drone trap (fig. 6) or by putting in one frame containing unsealed brood. Some bee keepers prefer using full sheets of foundation or even drawn combs for the artificial swarm, but narrow strips of foundation have some advantages. By using narrow strips the queen has no cells in which to lay eggs for a time, thus reducing brood rearing, but, since by the time artificial swarming is practiced the profitable brood rearing is usually over, this is no loss but rather a gain. There are also in the brood compartment no cells in which the gathering workers can deposit fresh honey, and they consequently put it in the supers. Gradually the combs below are built out and brood rearing is increased. Later the colony is allowed to put honey in the brood combs for its winter supply. If no increase is desired, the bees which emerge from the removed brood combs may later be united with the artificial swarm and by that time there will usually be little danger of natural swarming.

Artificial swarming can readily be combined with the shaking treatment for bee diseases, thus accomplishing two objects with one manipulation. If disease is present in the parent colony, only strips of foundation should be used and the colony should be confined to the hive with a queen and drone trap and not with a frame of brood.

PREVENTION OF SWARMING.

Unless increase is particularly desired, both natural and artificial swarming should be done away with as far as possible, so that the energy of the bees shall go into the gathering of honey. Since crowded and overheated hives are particularly conducive to swarming, this tendency may be largely overcome by giving plenty of ventilation and additional room in the hive. Shade is also a good preventive of swarming. Extra space in the hive may be furnished by adding more hive bodies and frames or by frequent extracting, so that there may be plenty of room for brood rearing and storage at all times. These manipulations are, of course, particularly applicable to extracted-honey production.

To curb the swarming impulse frequent examinations of the colonies (about every week or 10 days during the swarming season) for the purpose of cutting out queen cells is a help, but this requires considerable work, and since some cells may be overlooked, and particularly since it frequently fails in spite of the greatest care, it is not usually practiced. Requeening with young queens early in the season, when possible, generally prevents swarming.

Swarming is largely due to crowded brood chambers, and since eggs laid immediately before and during the honey flow do not produce gatherers, several methods have been tried of reducing the brood. The queen may either be entirely removed or be caged in the hive to prevent her from laying. In either event the bees will usually build queen cells to replace her, and these must be kept cut out. These plans would answer the purpose very well were it not for the fact that queenless colonies often do not work vigorously. Under most circumstances these methods can not be recommended. A better method is to remove brood about swarming time and thus reduce the amount. There are generally colonies in the apiary to which frames of brood can be given to advantage.

In addition to these methods various nonswarming devices have been invented, and later a nonswarming hive so constructed that there is no opportunity for the bees to form a dense cluster. The breeding of bees by selecting colonies with less tendency to swarm has been suggested.

On the whole, the best methods are the giving of plenty of room, shade, and ventilation to colonies run for extracted honey; and ventilation, shade, and artificial swarming of colonies run for comb honey. Frequent requeening (about once in two years) is desirable for other reasons, and requeening before swarming time helps in the solution of that difficulty.

PREPARATION FOR THE HARVEST.

An essential in honey production is to have the hive overflowing with bees at the beginning of the honey flow, so that the field force will be large enough to gather more honey than the bees need for their own use. To accomplish this, the bee keeper must see to it that brood rearing is heavy some time before the harvest, and he must know accurately when the honey flows come, so that he may time his manipulations properly. Brood rearing during the honey flow usually produces bees which consume stores, while brood reared before the flow furnishes the surplus gatherers. The best methods of procedure may be illustrated by giving as an example the conditions in the white-clover region.

In the spring the bees gather pollen and nectar from various early flowers, and often a considerable quantity from fruit bloom and dandelions. During this time brood rearing is stimulated by the new honey, but afterwards there is usually a period of drought when brood rearing is normally diminished or not still more increased as it should be. This condition continues until the white-clover flow comes on, usually with a rush, when brood rearing is again augmented. If such a condition exists, the bee keeper should keep brood rearing at a maximum by stimulative feeding during the drought. When white clover comes in bloom he may even find it desirable to prevent brood rearing to turn the attention of his bees to gathering.

A worker bee emerges from its cell 21 days after the egg is laid, and it usually begins field work in from 14 to 17 days later. It is evident, therefore, that an egg must be laid five weeks before the honey flow to produce a gatherer. Since the flow continues for some time and since bees often go to the field earlier than 14 days, egg laying should be pushed up to within two or three weeks of the opening of the honey flow. In addition to stimulative feeding, the care of the colony described under the heading of "Spring management" (p. 26) will increase brood production.

THE PRODUCTION OF HONEY.

The obtaining of honey from bees is generally the primary object of their culture. Bees gather nectar to make into honey for their own use as food, but generally store more than they need, and this surplus the bee keeper takes away. By managing colonies early in the spring as previously described the surplus may be considerably increased. The secret of maximum crops is to "Keep all colonies strong."

Honey is gathered in the form of nectar secreted by various flowers, is transformed by the bees, and stored in the comb. Bees also often gather a sweet liquid called "honeydew," produced by various scale insects and plant-lice, but the honeydew honey made from it is quite unlike floral honey in flavor and composition and should not be sold for honey. It is usually unpalatable and should never be used as winter food for bees, since it usually causes dysentery (p. 40). When nectar or honeydew has been thickened by evaporation and otherwise changed, the honey is sealed in the cells with cappings of beeswax.

It is not profitable to cultivate any plant solely for the nectar which it will produce, but various plants, such as clovers, alfalfa, and buckwheat, are valuable for other purposes and are at the same time excellent honey plants; their cultivation is therefore a benefit to the bee keeper. It is often profitable to sow some plant on waste land; sweet clovers are often used in this way. The majority of honey-producing plants are wild, and the bee keeper must largely accept the locality as he finds it and manage his apiary so as to get the largest possible amount of the available nectar. Since bees often fly as far as 2 or 3 miles to obtain nectar, it is obvious that the bee keeper can rarely influence the nectar supply appreciably. Before deciding what kind of honey to produce the bee keeper should have a clear knowledge of the honey resources of his locality and of the demands of the market in which he will sell his crop. If the bulk of the honey is dark, or if the main honey flows are slow and protracted, it will not pay to produce comb honey, since the production of fancy comb honey depends on a rapid flow. The best localities for comb-honey production are in the northern part of the United States east of the Mississippi River, where white clover is a rapid and abundant yielder. Other parts of the United States where similar conditions of rapidity of flow exist are also good. Unless these favorable conditions are present it is better to produce extracted honey.

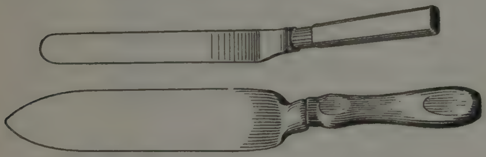

FIG. 21.—Knives for uncapping honey.

EXTRACTED HONEY.[1]

Extracted honey is honey which has been removed by means of centrifugal force from the combs in which the bees stored it. While it is possible to adulterate extracted honey by the addition of cheap sirups, this is rarely done, perhaps largely on account of the possibility of detection. It may be said to the credit of bee keepers as a class that they have always opposed adulteration of honey.

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[1] For further discussion of the production and care of extracted honey, see Bulletin 75, Part I, Bureau of Entomology.

In providing combs for the storage of honey to be extracted the usual practice is to add to the top of the brood chamber one or more hive bodies just like the one in which brood is reared, and fill these with frames. If preferred, shallower frames with bodies of proper size may be used, but most honey extractors are made for full-size frames. The surplus bodies should be put on in plenty of time to prevent the crowding of the brood chamber, and also to act as a preventive of swarming.

Honey for extracting should not be removed until it is well ripened and a large percentage of it capped. It is best, however, to remove the crop from each honey flow before another heavy producing plant comes into bloom, so that the different grades of honey may be kept separate. It is better to extract while honey is still coming in, so that the bees will not be apt to rob. The extracting should be done in a building, preferably one provided with wire cloth at the windows (p. 9).

The frames containing honey to be extracted are removed from the hive, the cappings cut off with a sharp, warm knife (fig. 21) made specially for this purpose, and the frames are then put into the baskets of the honey extractor (fig. 22). By revolving these rapidly the honey is thrown out of one side. The basket is then reversed and the honey from the other side is removed. The combs can then be returned to the bees to be refilled, or if the honey flow is over, they can be returned to the bees to be cleaned and then removed and stored until needed again. This method is much to be preferred to mashing the comb and straining out the honey, as was formerly done.

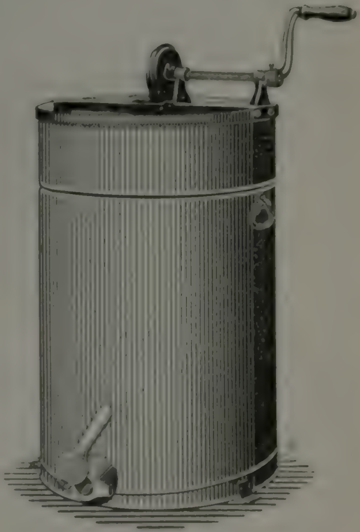

FIG. 22.—Honey extractor.

In large apiaries special boxes to receive cappings, capping melters to render the cappings directly into wax, and power-driven extractors are often used. These will be found listed in supply catalogues.

The extracted honey is then strained and run into vessels. It is advisable not to put it in bottles at once, but to let it settle in open vessels for a time, so that it can be skimmed. Most honeys will granulate and become quite hard if exposed to changes of temperature, and to liquefy granulated extracted honey it should be heated in a water bath. Never heat honey directly over a stove or flame, as the flavor is thereby injured. The honey should never be heated higher than 160° F. unless it is necessary to sterilize it because of contamination by disease.

Extracted honey is put up in bottles or small tin cans for the retail trade, and in 5-gallon square tin cans or barrels for the wholesale market. Great care must be exercised if barrels are used, as honey will absorb moisture from the wood, if any is present, and cause leakage. The tin package is much to be preferred in most cases. In bottling honey for retail trade, it will well repay the bee keeper or bottler to go to considerable expense and trouble to make an attractive package, as the increased price received will more than compensate for the increased labor and expense. Honey should be heated to 160° F. and kept there for a time before bottling, and the bottle should be filled as full as possible and sealed hermetically.

Granulated honey.—Some honeys, such as alfalfa, granulate quickly after being extracted. Such honeys are sometimes allowed to granulate in large cans and the semisolid mass is then cut into 1-pound bricks like a butter print and wrapped in paraffin paper. It may be put into paraffined receptacles before granulation, if desired. There is always a ready market for granulated honey, since many people prefer it to the liquid honey.

COMB HONEY.

Comb honey is honey as stored in the comb by the bees, the size and shape being determined by the small wooden sections provided by the bee keeper. Instead of having comb in large frames in which to store surplus honey, the bees are compelled to build comb in the sections and to store honey there (fig. 2). A full section weighs about 1 pound; larger ones are rarely used. By the use of modern sections and foundation the comb honey now produced is a truly beautiful, very uniform product, so uniform in fact that it is often charged that it must be artificially manufactured. The purchaser of a section of comb honey may be absolutely certain, however, that he is obtaining a product of the bees, for never has anyone been able to imitate the bees' work successfully. To show their confidence in the purity of comb honey, the National Bee Keepers' Association offers $1,000 for a single pound of artificial comb filled with an artificially prepared sirup, which is at all difficult of detection.

There are several different styles of sections now in use, the usual sizes being 4¼ inches square and 4 by 5 inches. There are also two methods of spacing, so that there will be room for the passage of bees from the brood chamber into the sections and from one super of sections to another. This is done either by cutting "bee ways" in the sections and using plain flat separators or by using "no beeway" or plain sections and using "fences"—separators with cleats fastened on each side, to provide the bee space. To describe all the different "supers" or bodies for holding sections would be impossible in a bulletin of this size, and the reader must be referred to catalogues of dealers in beekeeping supplies. Instead of using regular comb-honey supers, some bee keepers use wide frames to hold two tiers of sections. It is better, however, to have the supers smaller, so that the bees may be crowded more to produce full sections. To overcome this difficulty, shallow wide frames holding one tier of sections may be used. The majority of bee keepers find it advisable to use special comb-honey supers.

In producing comb honey it is even more necessary to know the plants which produce surplus honey, and just when they come in bloom, than it is in extracted honey production. The colony should be so manipulated that the maximum field force is ready for the beginning of the flow. This requires care in spring management, and, above all, the prevention of swarming. Supers should be put on just before the heavy flow begins. A good indication of the need of supers is the whitening of the brood combs at the top. If the bees are in two hive-bodies they should generally be reduced to one, and the frames should be filled with brood and honey so that as the new crop comes in the bees will carry it immediately to the sections above. If large hives are used for the brood chamber it is often advisable to remove some of the frames and use a division board to crowd the bees above. To prevent the queen from going into the sections to lay, a sheet of perforated zinc (fig. 23) may be put between the brood chamber and the super (fig. 2).

It is often difficult to get bees to begin work in the small sections, but this should be brought about as soon as possible to prevent loss of honey. If there are at hand some sections which have been partly drawn the previous year, these may be put in the super with the new sections as "bait." Another good plan is to put a shallow extracting frame on either side of the sections. If a few colonies in the apiary that are strong enough to go above refuse to do so, lift supers from some colonies that have started to work above and give them to the slow colonies. The super should generally be shaded somewhat to keep it from getting too hot. Artificial swarming will quickly force bees into the supers.

To produce the finest quality of comb honey full sheets of foundation should be used in the sections. Some bee keepers use nearly a full sheet hung from the top of the section and a narrow bottom starter. The use of foundation of worker-cell size is much preferred.

When one super becomes half full or more and there are indications that there will be honey enough to fill others, the first one should be raised and an empty one put on the hive under it. This tiering up can be continued as long as necessary, but it is advisable to remove filled sections as soon as possible after they are nicely capped, for they soon become discolored and less attractive. Honey removed immediately after capping finds a better market, but if left on the hive even until the end of the summer the quality of the honey is improved. A careful watch must be kept on the honey flow, so as to give the bees only enough sections to store the crop. If this is not done a lot of unfinished sections will be left at the end of the flow. Honeys from different sources should not be mixed in the sections, as it usually gives the comb a bad appearance

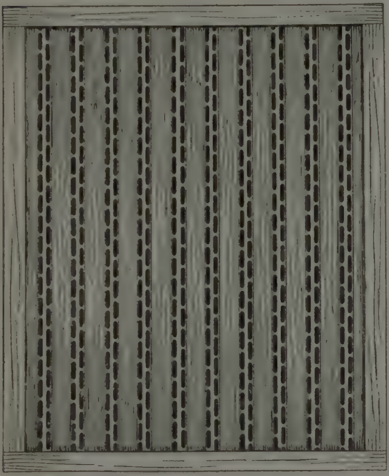

FIG. 23.—Perforated zinc queen excluder.

To remove bees from sections, the super may be put over a bee escape so that the bees can pass down but can not return, or the supers may be removed and covered with a wire-cloth-cone bee escape.

After sections are removed the wood should be scraped free of propolis (bee glue) and then packed in shipping cases (fig. 24) for the market. Shipping cases to hold 12, 24, or 48 sections, in which the various styles of sections fit exactly, are manufactured by dealers in supplies. In shipping these cases, several of them should be put in a box or crate packed in straw and paper and handles provided to reduce the chances of breakage. When loaded in a freight car the combs should be parallel with the length of the car.

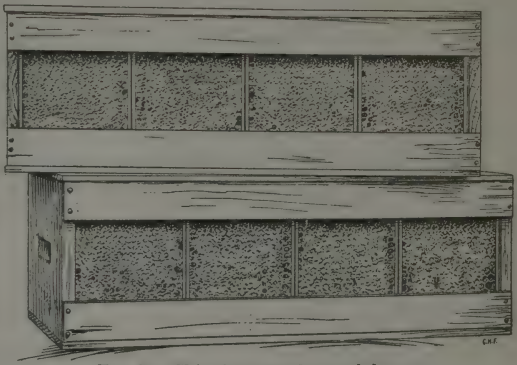

FIG. 24.—Shipping cases for comb honey.

In preparing comb honey for market it should be carefully graded so that the sections in each shipping case are as uniform as possible. Nothing will more likely cause wholesale purchasers to cut the price than to find the first row of sections in a case fancy and those behind of inferior grade. Grading rules have been adopted by various bee keepers' associations or drawn up by honey dealers. The following sets of rules are in general use:

Eastern Grading Rules for Comb Honey.

Fancy.—All sections well filled; combs straight; firmly attached to all four sides; the combs unsoiled by travel, stain, or otherwise; all the cells sealed except an occasional one; the outside surface of the wood well scraped of propolis.

A No. 1.—All sections well filled except the row of cells next to the wood; combs straight; one-eighth part of comb surface soiled, or the entire surface slightly soiled; the outside surface of the wood well scraped of propolis.

No. 1.—All sections well filled except the row of cells next to the wood; combs comparatively even; one-eighth part of comb surface soiled, or the entire surface slightly soiled.

No. 2.—Three-fourths of the total surface must be filled and sealed.

No. 3.—Must weigh at least half as much as a full-weight section.

In addition to this the honey is to be classified according to color, using the terms white, amber, and dark; that is, there will be "Fancy White," "No. 1 Dark," etc.

THE PRODUCTION OF WAX.

New Comb-Honey Grading Rules Adopted by the Colorado State Bee Keepers' Association.

No. 1 White.—Sections to be well filled and evenly capped, except the outside row, next to the wood; honey white or slightly amber, comb and cappings white, and not projecting beyond the wood; wood to be well cleaned; cases of separatored honey to average 21 pounds net per case of 24 sections; no section in this grade to weigh less than 13½ ounces. Cases of half-separatored honey to average not less than 22 pounds net per case of 24 sections. Cases of unseparatored honey to average not less than 23 pounds net per case of 24 sections.

No. 1 Light Amber.—Sections to be well filled and evenly capped, except the outside row next to the wood; honey white or light amber; comb and cappings from white to off color, but not dark; comb not projecting beyond the wood; wood to be well cleaned. Cases of separatored honey to average 21 pounds net per case of 24 sections; no section in this grade to weigh less than 13½ ounces. Cases of half-separatored honey to average not less than 22 pounds net per case of 24 sections. Cases of unseparatored honey to average not less than 23 pounds net per case of 24 sections.

No. 2.—This includes all white honey, and amber honey not included in the above grades; sections to be fairly well filled and capped, no more than 25 uncapped cells, exclusive of outside row, permitted in this grade; wood to be well cleaned; no section in this grade to weigh less than 12 ounces. Cases of separatored honey to average not less than 19 pounds net. Cases of half-separatored honey to average not less than 20 pounds net per case of 24 sections. Cases of unseparatored honey to average not less than 21 pounds net per case of 24 sections.

Beeswax, which is secreted by the bees and used by them for building their combs, is an important commercial product. There are times in almost every apiary when there are combs to be melted up, and it pays to take care of even scraps of comb and the cappings taken off in extracting. A common method of taking out the wax is to melt the combs in a solar wax extractor. This is perhaps the most feasible method where little wax is produced, but considerable wax still remains in old brood combs after such heating. Various wax presses are on the market, or one can be made at home. If much wax is produced, the bee keeper should make a careful study of the methods of wax extraction, as there is usually much wax wasted even after pressing.

PREPARATIONS FOR WINTERING.

After the main honey flow is over the management must depend on what may be expected later in the season from minor honey flows. If no crop is to be expected, the colony may well be kept only moderately strong, so that there will not be so many consumers in the hive.

In localities where winters are severe and breeding is suspended for several months great care should be taken that brood rearing is rather active during the late summer, so that the colony may go into winter with plenty of young bees. In case any queens show lack of vitality they should be replaced early, so that the bees will not become queenless during the winter.

The important considerations in wintering are plenty of young bees, a good queen, plenty of stores of good quality, sound hives, and proper protection from cold and dampness.

If, as cold weather approaches, the bees do not have stores enough, they must be fed. Every colony should have from 25 to 40 pounds, depending on the length of winter and the methods of wintering. It is better to have too much honey than not enough, for what is left is good next season. If feeding is practiced, honey may be used, but sirup made of granulated sugar is just as good and is perfectly safe. If honey is purchased for feeding, great care should be taken that it comes from a healthy apiary, otherwise the apiary may be ruined by disease. *Never feed honey bought on the open market.* The bees should be provided with stores early enough so that it will not be necessary to feed or to open the colonies after cold weather comes on. Honeydew honey should not be left in the hives, as it produces "dysentery." Some honeys are also not ideal for winter stores. Those which show a high percentage of gums (most tree honeys) are not so desirable, but will usually cause no trouble.

In wintering out of doors the amount of protection depends on the severity of the winter. In the South no packing is necessary, and even in very cold climates good colonies with plenty of stores can often pass the winter with little protection, but packing and protection make it necessary for the bees to generate less heat, and consequently they consume less stores and their vitality is not reduced. Dampness is probably harder for bees to withstand than cold, and when it is considered that bees give off considerable moisture, precautions should be taken that as it condenses it does not get on the cluster. An opening at the top would allow the moisture to pass out, but it would also waste heat, so it is better to put a mat of burlap or other absorbent material on top of the frames. The hive may also be packed in chaff, leaves, or other similar dry material to diminish the loss of heat. Some hives are made with double walls, the space being filled with chaff; these are good for outdoor wintering. The hive entrance should be lower than any other part of the hive, so that any condensed moisture may run out. The hives should be sound and the covers tight and waterproof.

Entrances should be contracted in cold weather not only to keep out cold wind, but to prevent mice from entering. There should always be enough room, however, for bees to pass in and out if warmer weather permits a flight.

In the hands of experienced bee keepers cellar wintering is very successful, but this method requires careful study. The cellar must be dry and so protected that the temperature never varies more than from 40 to 45° F.; 43° F. seems to be the optimum temperature. The ventilation must be good or the bees become fretful. Light should not be admitted to the cellar, and consequently some means of indirect ventilation is necessary.

Cellar wintering requires the consumption of less honey to maintain the proper temperature in the cluster and is therefore economical. Bees so wintered do not have an opportunity for a cleansing flight, often for several months, but the low consumption makes this less necessary. Some bee keepers advocate carrying the colonies out a few times on warm days, but it is not fully established whether this is entirely beneficial and it is usually not practiced.

The time for putting colonies in the cellar is a point of dispute, and practice in this regard varies considerably. They should certainly be put in before the weather becomes severe and as soon as they have ceased brood rearing. The time chosen may be at night when they are all in the hive, or on some chilly day.

The hives may be piled one on top of the other, the lower tier raised a little from the floor. The entrances should not be contracted unless the colony is comparatively weak. It is usually not considered good policy to close the entrances with ordinary wire cloth, as the dead bees which accumulate more or less on the bottom boards may cut off ventilation, and the entrance should be free so that these may be cleaned out.

It is, however, good policy to cover the entrance with wire cloth having three meshes to the inch to keep out mice.

The time of removing bees from the cellar is less easily determined than that of putting them in. The colonies may be removed early and wrapped in *black* tar paper or left until the weather is settled. If the weather is very warm and the bees become fretful, the cellar must either be cooled or the bees removed. Some bee keepers prefer to remove bees at night, so that they can recover from the excitement and fly from the hive normally in the morning. One of the chief difficulties is to prevent the bees from getting into the wrong hives after their first flights. They often "drift" badly with the wind, and sometimes an outside row will become abnormally strong, leaving other colonies weak.

The night before the bees are removed from the cellar it is good practice to leave the cellar doors and windows wide open.

DISEASES AND ENEMIES.

There are two infectious diseases of the brood of bees which cause great losses to the beekeeping industry of the United States. These are known as American foul brood and European foul brood. Both of these diseases destroy colonies by killing the brood, so that there are not enough young bees emerging to take the place of the old adult bees as these die from natural causes. The adult bees are not attacked by either disease. In the hands of careful bee keepers both diseases may be controlled, and this requires careful study and constant watching. In view of the fact that these diseases are now widely distributed throughout the United States, every bee keeper should read the available literature on the subject, so that if disease enters his apiary he may be able to recognize it before it gets a start. The symptoms and the treatment recommended by this department are given in another publication which will be sent free on request.[1]

It is difficult for a bee keeper to keep his apiary free from disease if others about him have diseased colonies which are not properly treated. The only way to keep disease under control is for the bee keepers in the neighborhood to cooperate in doing everything possible to stamp out disease as soon as it appears in a single colony. The progressive bee keeper who learns of disease in his neighborhood should see to it that the other bee keepers around him are supplied with literature describing symptoms and treatment, and should also try to induce them to unite in eradicating the malady. Since it is so often impossible to get all of the bee keepers in a community to treat infected colonies properly and promptly, it is desirable that the States pass laws providing for the inspection of apiaries and granting to the inspector the power to compel negligent bee keepers to treat diseased colonies so that the property of others may not be endangered and destroyed. This has been done in a number of States, but there are still some where the need is great and in which no such provision has been made. When no inspection is provided, bee keepers should unite in asking for such protection, so that the danger to the industry may be lessened.

In case there is an inspector for the State or county, he should be notified as soon as disease is suspected in the neighborhood. Some bee keepers hesitate to report disease through fear that the inspector will destroy their bees or because they feel that it is a disgrace to have disease in the apiary. There is no disgrace in having colonies become diseased; the discredit is in not treating them promptly. The inspectors are usually, if not universally, good practical bee keepers who from a wide experience are able to tell what should be done in individual cases to give the best results with the least cost in material and labor. They do not destroy colonies needlessly, and, in fact, they all advocate and teach treatment.

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[1] Farmers' Bulletin No. 442, "The Treatment of Bee Diseases."

The brood diseases are frequently introduced into a locality by the shipping in of diseased colonies; or, more often, the bees get honey from infected colonies which is fed to them, or which they rob, from discarded honey cans. It is decidedly dangerous to purchase honey on the market, with no knowledge of its source, to be used in feeding bees. Many outbreaks of disease can be traced to this practice (see "Feeding," p. 26). It is difficult to prevent bees from getting contaminated honey accidentally. If colonies are purchased, great care should be taken that there is no disease present. Whenever possible, colonies should be purchased near at home, unless disease is already present in the neighborhood.

There are other diseased conditions of the brood, known to bee keepers as "pickle brood," but these can usually be distinguished from the two diseases previously mentioned. The so-called "pickle brood" is not contagious and no treatment is necessary. Bees also suffer from "dysentery," which is discussed in the earlier part of this bulletin, and from the so-called "paralysis," a disease of adult bees. No treatment for the latter disease can as yet be recommended as reliable. The sprinkling of powdered sulphur on the top bars of frames or at the entrance is sometimes claimed to be effective, but under what circumstances it is beneficial is unknown.

A number of insects, birds, and mammals must be classed as enemies of bees, but of these the two wax moths, and ants, are the only ones of importance. There are two species of moth, the larger wax moth (*Galleria mellonella* L.), and the lesser wax moth (*Achroia grisella* Fab.), the larvæ of which destroy combs by burrowing through them.[1] Reports are frequently received in the department that the larvæ of these moths (usually the larger species) are destroying colonies of bees. It may be stated positively that moths do not destroy strong, healthy colonies in good hives, and if it is supposed that they are causing damage the bee keeper should carefully study his colonies to see what other trouble has weakened them enough for the moths to enter. Queenlessness, lack of stores, or some such trouble may be the condition favorable to the entrance of the pest, but a careful examination should be made of the brood to see whether there is any evidence of disease. This is the most frequent cause of the cases of moth depredation reported to this department. Black bees are less capable of driving moth larvæ out, but, even with these bees, strong colonies rarely allow them to remain. The observance of the golden rule of bee keeping, "Keep all colonies strong," will solve the moth question unless disease appears.

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[1] Bee keepers refer to these insects as "moths," "wax moths," "bee moths," "millers," "wax worms," "honey moths" "moth worms," "moth millers," and "grubs." The last six terms are not correct.

Moth larvæ often destroy combs stored outside the hive. To prevent this the combs may be fumigated with sulphur fumes or bisulphid of carbon in tiers of hives or in tight rooms. If bisulphid of carbon is used, great care should be taken not to bring it near a flame, as it is highly inflammable. Combs should be stored in a dry, well-ventilated, light room.

In the warmer parts of the country ants are often a serious pest. They may enter the hive for protection against changes of temperature, or to prey on the honey stores or the brood. The usual method of keeping them out is to put the hive on a stand, the legs of which rest in vessels containing water or creosote. Another method is to wrap a tape soaked in corrosive sublimate around the bottom board.

GENERAL INFORMATION.

For the purpose of answering numerous questions which are asked of this department the following brief topics are included.

BREEDERS OF QUEENS.

There are a large number of bee keepers who make a business of rearing queens of good stock for sale. The queens are usually sent by mail. If poor stock is all that can be obtained locally, it is recommended that such colonies be purchased and the queens removed and replaced with those obtained from a good breeder. This department can supply names of breeders, nearest the applicant, of any race raised in this country.

INTRODUCING QUEENS.

When queens are shipped by mail they usually come in cages (fig. 25) which can be used for introducing. If the colony to receive the new queen has one, she must be removed and the cage inserted between the frames. The small hole leading into the candy compartment is uncovered, and the bees gradually eat through and release the queen. If queens are reared at home, a similar cage may be used for introducing. In view of the fact that disease may be transmitted in mailing cages, it is always a wise precaution to remove the new queen and destroy the accompanying workers and the cage and its contents. The queen may then be put into a clean cage without worker bees, with candy known to be free from contamination (made from honey from healthy hives), and introduced in the regular way.

Queens sold by breeders are always mated unless otherwise specified, and consequently the colony in which they are introduced has no effect on her offspring. During the active season the bees in the colony are all the offspring of the new queen in about nine weeks. Three weeks is required for the previous brood to emerge (if the colony has not been queenless), and in six weeks after all the old brood emerges most of the workers from it will have died. Queens are usually sold according to the following classification:

"*Untested queen*"—one that has mated, but the race of the drone is not known.

"*Tested queen*"—one that has mated and has been kept only long enough to show, from the markings of her progeny, that she mated with a drone of her own race.

"*Breeding queen*"—a tested queen which has shown points of superiority, making her desirable for breeding purposes.

DEALERS IN BEE KEEPERS' SUPPLIES.

There are several manufacturers of supplies in this country who can furnish almost anything desired by the bee keeper. Some of them have agents in various parts of the country from whom supplies may be purchased, thus saving considerable in freight.

BEE KEEPERS' ASSOCIATIONS.

There are a large number of associations of bee keepers in all parts of the country, formed for the betterment of the industry, and a few associations which are organized to aid the members in purchasing supplies and in selling the crops. Of these the National Bee Keepers' Association is the largest. It helps its members in obtaining their legal rights, and aids in securing legislation for the furtherance of the industry. The annual conventions are held in different parts of the country, and copies of the proceedings are sent to the members. There are also numerous State, county, and town associations, some of which publish proceedings. The names of officers of the nearest associations or of the National Bee Keepers' Association will be sent from this department on request.

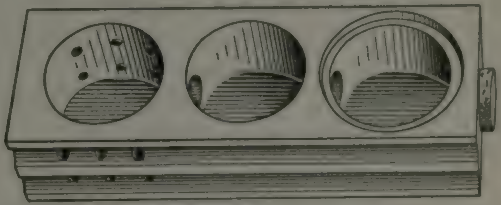

FIG. 25.—Queen mailing cage.

LAWS AFFECTING BEEKEEPING.

Disease inspection.—Various States have passed laws providing for the State or county inspection of apiaries for bee-disease control, and every bee keeper should get in touch with an inspector when disease is suspected, if one is provided. The inspectors are practical bee keepers who fully understand how to control the diseases, and are of great help in giving directions in this matter. The name of the inspector of any locality can usually be furnished, and this department is glad to aid bee keepers in reaching the proper officers.

Laws against spraying fruit trees while in bloom.—The spraying of fruit trees while in bloom is not now advised by economic entomologists, and to prevent the practice some States have passed laws making it a misdemeanor. Such spraying not only kills off honey bees, causing a loss to the bee keeper, but interferes with the proper pollination of the blossoms and is thus a detriment to the fruit grower. Bee keepers should do everything in their power to prevent the practice.

Laws against the adulteration of honey.—The national food and drugs act of 1906, and various State pure food laws, are a great aid to the bee keeper in preventing the sale of adulterated extracted honey as pure honey. Bee keepers can often aid in this work by reporting to the proper officials infringements of these laws which come to their notice.

When bees are a nuisance.—Some cities have passed ordinances prohibiting the keeping of bees in certain areas, but so far none has been able to enforce them. If bees are a nuisance in individual cases, the owner may be compelled to remove them. The National Bee Keepers' Association will help any of its members in such cases, if they are in the right, as well as in cases where bees sting horses. Bee keepers should be careful not to locate bees where they can cause any trouble of this kind.

SUPPOSED INJURY OF CROPS BY BEES.

Bee keepers are often compelled to combat the idea that bees cause damage to fruit or other crops by sucking the nectar from the flower. This is not only untrue, but in many cases the bees are a great aid in the pollination of the flowers, making a good crop possible. A more frequent complaint is that bees puncture fruit and suck the juices. Bees never puncture sound fruit, but if the skin is broken by some other means bees will often suck the fruit dry. In doing it, however, they are sucking fruit which is already damaged. These and similar charges against the honey bee are prompted by a lack of information concerning their activities. Bees may, of course, become a nuisance to others through their stinging propensities, but bee keepers should not be criticized for things which their bees do not do.

JOURNALS AND BOOKS ON BEEKEEPING.

The progressive bee keeper will find it to his profit to subscribe for at least one journal devoted to beekeeping. Several of these are published in the United States. The names and addresses of such journals may usually be obtained from a subscription agent for periodicals, or from a supply dealer.

It will also be advantageous to read and study books on beekeeping, of which several are published in this country. These are advertised in journals devoted to beekeeping, or may usually be obtained through the local book dealer or through dealers in bee keepers' supplies.

PUBLICATIONS OF THE DEPARTMENT OF AGRICULTURE ON BEE KEEPING.[1]

There are several publications of this department which are of interest to bee keepers, and new ones are added from time to time in regard to the different lines of investigation.

The following publications relating to bee culture, prepared in the Bureau of Entomology, are for free distribution and may be obtained by addressing the Secretary of Agriculture:[2]

Farmers' Bulletin No. 447, "Bees." By E. F. Phillips, Ph. D. 1911. 48 pp., 25 figs.

A general account of the management of bees.

Farmers' Bulletin No. 442, "The Treatment of Bee Diseases." By E. F. Phillips, Ph. D. 1911. 22 pp., 7 figs.

This publication gives briefly the symptoms of the various bee diseases, with directions for treatment.

Circular No. 94, "The Cause of American Foul Brood." By G. F. White, Ph. D. 1907. 4 pp.

This publication contains a brief account of the investigations which demonstrated for the first time the cause of one of the brood diseases of bees, American foul brood.

Circular No. 138. "The Occurrence of Bee Diseases in the United States. (Preliminary Report.)" By E. F. Phillips, Ph. D. 1911. 25 pp.

A record of the localities from which samples of diseased brood were received prior to March 1, 1911.

Bulletin No. 55, "The Rearing of Queen Bees." By E. F. Phillips, Ph. D. 1905. 32 pp., 17 figs.

A general account of the methods used in queen rearing. Several methods are given, so that the bee keeper may choose those best suited to his individual needs.

Bulletin No. 70, "Report of the Meeting of Inspectors of Apiaries, San Antonio, Tex., November 12, 1906." 1907. 79 pp., 1 plate.

Contains a brief history of bee-disease investigations, an account of the relationship of bacteria to bee diseases, and a discussion of treatment by various inspectors of apiaries and other practical bee keepers who are familiar with diseases of bees.

Bulletin No. 75, Part I, "Production and Care of Extracted Honey." By E. F. Phillips, Ph. D. "Methods of Honey Testing for Bee Keepers." By C. A. Browne, Ph. D. 1907. 18 pp.

The methods of producing extracted honey, with special reference to the care of honey after it is taken from the bees, so that its value may not be decreased by improper handling. The second portion of the publication gives some simple tests for adulteration.

Bulletin No. 75, Part II, "Wax Moths and American Foul Brood." By E. F. Phillips, Ph. D. 1907. Pp. 19-22, 3 plates.

An account of the behavior of the two species of wax moths on combs containing American foul brood, showing that moths do not destroy the disease-carrying scales.

Bulletin No. 75, Part III, "Bee Diseases in Massachusetts." By Burton N. Gates. 1908. Pp. 23-32, map.

An account of the distribution of the brood diseases of bees in the State, with brief directions for controlling them.

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[1] List revised to April 1, 1911. (VII.)

[2] Farmers' Bulletin No. 59, "Bee Keeping," and Farmers' Bulletin No. 397, "Bees," have been superseded by Farmers' Bulletin No. 447.

Circular No. 79, "The Brood Diseases of Bees," has been superseded by Farmers' Bulletin No. 442. Bulletin No. 1, "The Honey Bee," has been discontinued.

Bulletin No. 75, Part IV, "The Relation of the Etiology (Cause) of Bee Diseases to the Treatment." By G. F. White, Ph. D. 1908. Pp. 33–42.

The necessity for a knowledge of the cause of bee diseases before rational treatment is possible is pointed out. The present state of knowledge of the causes of disease is summarized.

Bulletin No. 75, Part V, "A Brief Survey of Hawaiian Bee Keeping." By E. F. Phillips, Ph. D. 1909. Pp. 43–58, 6 plates.

An account of the beekeeping methods used in a tropical country and a comparison with mainland conditions. Some new manipulations are recommended.

Bulletin No. 75, Part VI, "The Status of Apiculture in the United States." By E. F. Phillips, Ph. D. 1909. Pp. 59–80.

A survey of present-day beekeeping in the United States, with suggestions as to the work yet to be done before apiculture will have reached its fullest development.

Bulletin No. 75, Part VII, "Bee Keeping in Massachusetts." By Burton N. Gates. 1909. Pp. 81–109, 2 figs.

An account of a detailed study of the apicultural conditions in Massachusetts. The object of this paper is to point out the actual conditions and needs of beekeeping in New England.

Bulletin No. 75, Contents and Index. 1911. Pp. VIII+111–123.

Bulletin No. 75, Parts I–VII, complete with Contents and Index. 1911. Pp. VIII+123.

Bulletin No. 98. "Historical Notes on the Causes of Bee Diseases." By E. F. Phillips, Ph. D., and G. F. White, Ph. D., M. D. (In press.)

A summary of the various investigations concerning the etiology (cause) of bee diseases.

Technical Series, No. 14, "The Bacteria of the Apiary, with Special Reference to Bee Diseases." By G. F. White, Ph. D. 1906. 50 pp.

A study of the bacteria present in both the healthy and the diseased colony, with special reference to the diseases of bees.

Technical Series No. 18, "The Anatomy of the Honey Bee." By R. E. Snodgrass. 1910. 162 pp., 57 figs.

An account of the structure of the bee, with technical terms omitted so far as possible. Practically all of the illustrations are new, and the various parts are interpreted according to the best usage in comparative anatomy of insects. A brief discussion of the physiology of the various organs is included.

BUREAU OF CHEMISTRY.

Bulletin No. 110, "Chemical Analysis and Composition of American Honeys." By C. A. Browne. Including "A Microscopical Study of Honey Pollen." By W. J. Young. 1908. 93 pp., 1 fig., 6 plates.

A comprehensive study of the chemical composition of American honeys. This publication is technical in nature and will perhaps be little used by practical bee keepers, but it is an important contribution to apicultural literature. By means of this work the detection of honey adulteration is much aided.]

HAWAII AGRICULTURAL EXPERIMENTAL STATION, HONOLULU, HAWAII.

Bulletin No. 17, "Hawaiian Honeys." By D. L. Van Dine and Alice R. Thompson. 1908. 21 pp., 1 plate.

A study of the source and composition of the honeys of Hawaii. The peculiar conditions found on these islands are dealt with.

[A list giving the titles of all Farmers' Bulletins available for distribution will be sent free upon application to a Member of Congress or the Secretary of Agriculture.]

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Issued June 14, 1911.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 448.

BETTER GRAIN-SORGHUM CROPS.

BY

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WASHINGTON:
GOVERNMENT PRINTING OFFICE
1911.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., March 13, 1911.

Sir: I have the honor to transmit and to recommend for publication as a Farmers' Bulletin the accompanying manuscript on "Better Grain-Sorghum Crops," prepared by Mr. Carleton R. Ball, Agronomist in Charge of Grain-Sorghum Investigations, under the direction of Mr. M. A. Carleton, Cerealist in Charge of Grain Investigations.

The areas devoted to grain sorghums in the dry regions of the Southwest are rapidly increasing. The importance of these crops, however, is even greater than can be measured in terms of increased acreage. They are staple crops in much of the new dry-farming area of the southern Plains region and other parts of the Southwest. In many cases they are the chief dependence of the new settler, and their success or failure determines his ability to become established.

This paper presents the best known methods of improving the grain-sorghum crops on the farms where they are grown. These methods are simple and inexpensive of time or money, and are therefore within the reach of all farmers. More attention to the bettering of the quality and yields will be repaid as fully in these crops as in other cereals.

Respectfully,

Wm. A. Taylor,
Acting Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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B. P. I.—657.

BETTER GRAIN-SORGHUM CROPS

INTRODUCTION.

The aim of this paper is to tell the farmer who is growing grain sorghums how he can best improve these crops. By grain sorghums is meant all the different varieties of the groups of sorghums called milo, kafir, durra, and kowliang. Of these groups only the kafirs are grown to any extent for forage, apart from the grain. The other groups are grown almost wholly for the yields of grain.

By improvement is meant changes both in the habits of the plants themselves and in the methods of handling them. These changes must be such as will make them better yielders or otherwise better adapted to the needs of the grower. Some of these changes will be in the matter of purer varieties, greater drought resistance, increased earliness, dwarfer stature, better heads, thinner seeding, and machine harvesting.

In many localities unimproved varieties of grain sorghums are being grown. Most farmers can improve their local varieties. Some of them do so to a very creditable extent; others neglect this entirely. Such work should be much more generally done, and probably would be if the methods of doing it were more commonly understood. In other communities improved varieties have been introduced and are grown by most of the farmers. The work of improving them must be continued by the growers, however, or the varieties are likely to become gradually poorer. This is caused by accidental mixtures of seed or by crossing with other varieties or with unimproved strains of the same variety.

The annual loss from smut is serious, in the kafir varieties, especially, though it may readily be prevented. The milo varieties are not affected by smut under any circumstances.

Before taking up the study of methods of improvement it is desirable to consider the region in which these crops are grown and to know something of their origin, history, general adaptations, and importance.

THE GRAIN-SORGHUM BELT.

The grain sorghums are most largely grown in the southern half of the Great Plains region (fig. 1).

BOUNDARIES.

Broadly speaking, this region includes the plain lying between the ninety-eighth meridian of longitude and the Rocky Mountains. The southern half of it may be said to include the area between the northern boundary of Kansas and the Mexican border, although the extreme southern part of western Texas does not belong to the Plains proper. The area thus bounded takes in the western half of Kansas, the western third of Oklahoma, the western half of Texas, and all of Colorado and New Mexico lying east of the mountains. In round numbers it is 400 miles wide and 1,000 miles long. So important are these crops in this area that it may well be called the "grain-sorghum belt."

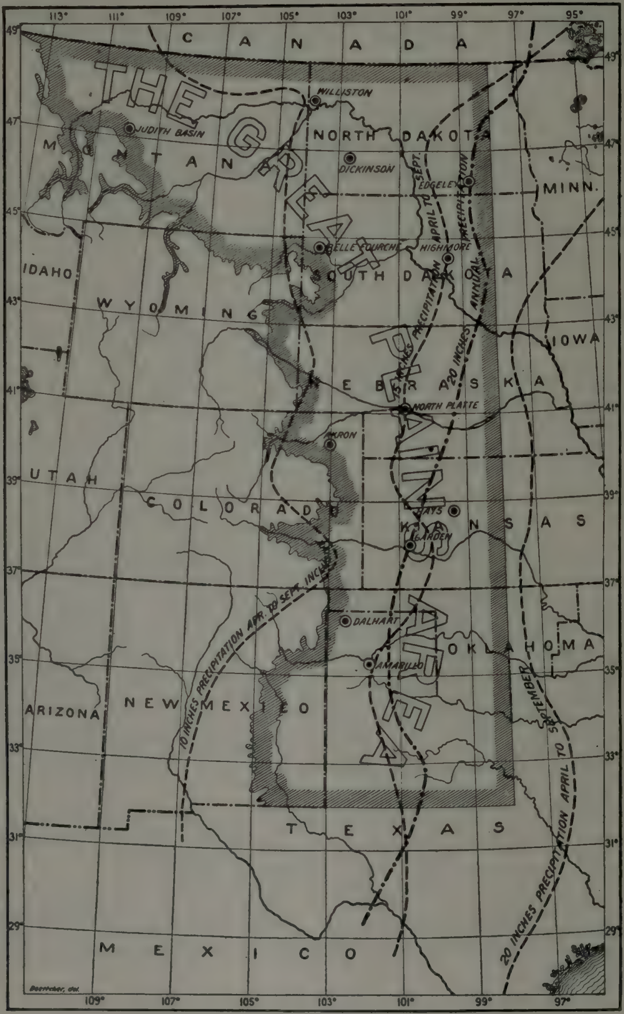

FIG. 1.—Map of the Great Plains area, showing the annual and the seasonal rainfall.

SURFACE FEATURES.

The surface of the area just outlined is in general a gently rolling plain, sloping steadily eastward from an elevation of 4,000 to 5,000 feet at the base of the Rockies to an average elevation of 1,000 to

1,500 feet at the ninety-eighth meridian. The highest section in these plains is not at the base of the mountains but some distance east of them, in Elbert and El Paso Counties, Colo., where the altitude increases to nearly or quite 6,500 feet. While the main slope is toward the east, there is also a secondary slope to the north and south from this high area in Colorado. Looked at from above, the surface of the whole Great Plains region may be compared in outline to half of an inverted saucer, the rim lying toward the east.

SOILS AND PLANT COVERING.

The soils of this region vary from the dark clays of the central Panhandle and the red clays of western Oklahoma, through sandy loams found in scattered areas throughout the whole region, to very sandy soils such as characterize the sand-hill country of Kansas and Colorado.

The plant covering of the loams and clays is mostly a dense sod of buffalo grass and blue grama mixed. In general these are called "tight" lands or "short-grass" country. In southwest Texas the buffalo grass gives place to the curly mesquite (*Hilaria cenchroides*), or running mesquite, as it is often called. On the more sandy soils are found taller and more bunchy grasses, such as the bluestems (*Andropogon* spp.) and the needle grasses, or wire-grasses (*Aristida* spp.). In much of western Texas the plains have been largely covered by a more or less dense growth of the mesquite tree (Prosopis). In southern Texas this becomes a large tree, but as it ascends to the higher plains its size diminishes until in the upper Panhandle it is only a low shrub or bush.

CLIMATE.

What really seperates the so-called Great Plains region from the country lying immediately east of it is, primarily, not differences in either elevation or soil, but the lower rainfall and higher evaporation of moisture. The average annual rainfall for the grain-sorghum belt, as defined above, is about 20 inches, varying in different parts from 15 to 25 inches, of which more than half comes in the months of April to September, inclusive. (See fig. 1.) The summer temperature is fairly high, and this, with the steady winds which prevail over much of this area, makes evaporation rapid and continuous.

All crops to be suitable for use in this area must have the ability either to withstand or to escape drought in one way or another. Dry, hot winds occasionally occur in some parts of the region, often quickly and completely destroying all tender vegetation. At the higher elevations and in the northern part generally the season is comparatively short. Late spring frosts occur and the first frosts of autumn come rather early. Early varieties must therefore be used.

AGRICULTURAL DEVELOPMENT.

The process of dividing the great cattle ranges and selling them for farms is going on steadily. Wherever Government land remains, homesteads are being taken up. In the past few years the settlement of this dry country has been very rapid. Rapid settlement may be desirable; it is much more important, however, that it be permanent. This has not always been the case. More than once considerable areas have been largely abandoned after having been quite well settled and improved. The abandoned farms reverted first to weed crops and finally to grass and sod. These conditions were true in the early eighties and again in the early nineties. The principal cause was a series of unusually dry seasons. Loss of crops starved out many settlers who had little capital to carry them through such crises.

It is quite probable that such unfavorable periods will occur again. Plains settlers must prepare to endure them with as little loss as possible. In two important ways the farmer is much better equipped than he was 15 or 20 years ago. Better and more drought-resistant crops and crop varieties have been found or produced, and better methods of tilling the land in dry regions have been developed.

No one may say with certainty just what the agricultural future of this southern Plains region is to be. It gives promise of becoming a second great feeding belt, similar to the corn belt. The comparatively mild winters and nutritious grasses which made it a famous grazing country will help to make it a famous feeding area. It is true that the native range carries only one head of stock the year round on each 25 to 50 acres, owing to the small size and slow growth of the grasses. However, the carrying capacity per acre may be enormously increased by supplementing the native pasture with crops supplying forage and feeding grains.

Nothing better could be wished than that this area should grow stock and the crops to feed them. Under such a system of farming it would produce many more live stock than it ever did or could under the ranch and range system. If it should raise a money crop in addition, so much the better. This might be cotton in the southern part, winter wheat in the central, and spring wheat in the northern part, with broom corn and other minor crops in different parts. The area is admirably adapted to growing both the stock and the necessary feeding crops.

IMPORTANCE OF THE GRAIN-SORGHUM CROP.

The following pages give briefly the history of the grain sorghums in the United States, the general conditions to which they are adapted, and some statistics of their acreage, yield, and value.

HISTORY OF THE VARIETIES.

It is only 35 years since the first grain sorghums (fig. 2) were introduced into the United States. It is only 20 years since any of them have become crops of recognized importance. Although grain-producing varieties had probably been introduced from time to time since the early colonial days, none had remained in cultivation.

The first permanent introductions were the two durras, Brown durra and White durra, which reached California in 1874 under the names "Brown Egyptian corn" and "White Egyptian corn." On account of its earliness and drought resistance, the white variety became popular in the central Plains region during two different series of dry years. The first was from 1880 to 1884, when it was known as "Rice corn." Again, 10 years later, it was rather widely grown under the name "Jerusalem corn." Both the white and the brown varieties, but especially the white, are still sparingly grown in the dry Southwest, from Kansas to California. That they did not remain in general cultivation is probably due to the ready shattering of the seed when ripe and to the irritating hairs on the glumes.

Two varieties of kafir, the White and the Red, were brought from South Africa in 1876. They did not come into general cultivation in the Plains until about 1890, 14 years later. The Blackhull kafir appeared soon after, but whether it was a part of the original importation, separated by selection, or was a later introduction will probably never be known. The original White kafir is rarely found in cultivation to-day, but the Red and the Blackhull are important crops.

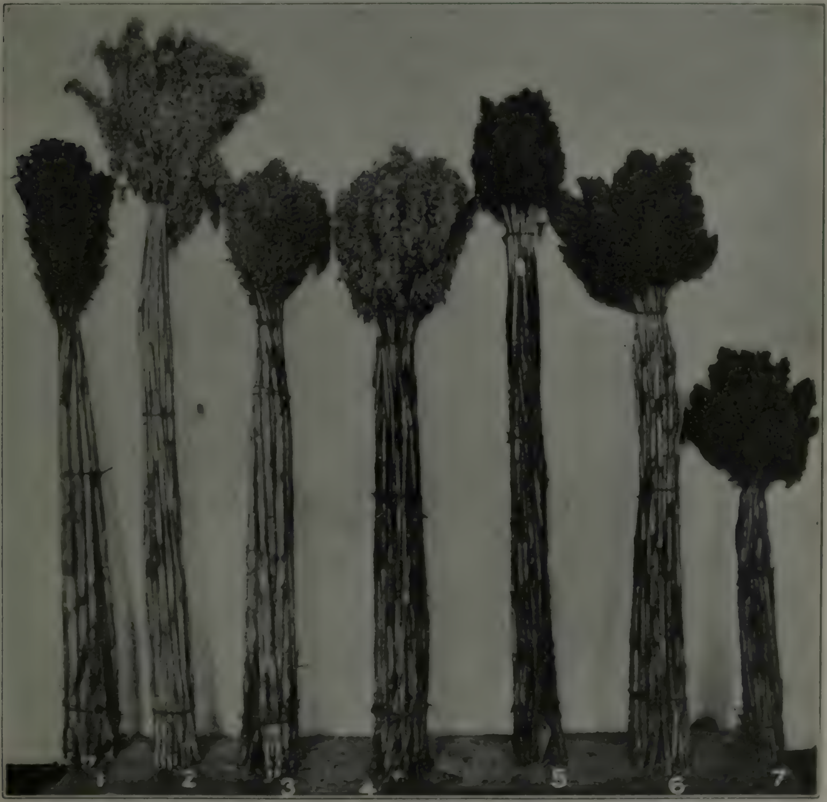

FIG. 2.—Sheaves of improved grain sorghums: 1. Red kafir; 2. Shallu; 3. Blackhull kafir, 4. White durra; 5. Brown kowliang; 6. Milo; 7. Dwarf Milo.

Milo was first introduced into South Carolina or Georgia about the year 1885, but did not come into general notice until about 1890, when it had become a staple crop in parts of west Texas.

The kowliangs have been coming from China and Manchuria since 1901. Most of them have required considerable selection to make them suitable for use as grain crops. None of them has been long enough in the hands of farmers to be considered a farm crop.

In the brief space of the last 20 years, however, the milos and kafirs have greatly increased in importance. They are now grown as staple farm crops on a large scale in a considerable area of the West.

ADAPTATIONS TO THE GRAIN-SORGHUM BELT.

It is in the region described that the grain sorghums prove themselves most completely at home. They are not only staple crops here, but are in many cases the chief dependence of the new settler. This is because they may be grown as sod crops. By homesteaders with small means and limited equipment they can be cheaply planted on breaking. They are often planted, cultivated, harvested, and even thrashed by hand under such circumstances.

When these crops were first introduced they were tried in various parts of the United States. One after another they were found unsuited to the conditions in most of the country and were discarded; but out on the Plains they grew in favor with the farmer because they were able to withstand the prevailing conditions. They are able to grow and make profitable yields in hotter, drier climates than most crops. Some of them are early enough for use at comparatively high elevations. They are all cultivated crops, entering readily into the rotation with spring-sown small grains. They furnish the feeding grain required on the farm; also some roughage, and occasionally both fuel and food in addition. The surplus can always be sold at fair to good prices. When grown on a large scale they are handled rapidly and profitably by machinery in every necessary operation from seeding to milling. They are undoubtedly suited to become the basis of a cattle-feeding industry that will make the Plains farmer prosperous.

USES OF THE GRAIN.

STOCK FEED.

Primarily these grains are and ought to be used in feeding stock on the farms where they are grown. This fact is due to their history as well as to their adaptations for such use. They were the principal crops of the early settler in the dry-land areas of the southern Plains region. He not only needed a feeding grain, but was often too far from market to sell profitably if he had wished.

The value of the grain for keeping work stock, growing animals, and dairy cows in excellent condition has long been recognized among the growers. The knowledge of its value in fattening cattle and hogs for market is increasing. A number of experiments to determine the feeding value have been conducted at the agricultural experiment stations of Kansas,[1] Oklahoma,[2] and Texas.[3] In many of these trials the Blackhull-kafir grain, which was most generally used, was shown to have a feeding value but little below that of corn. Chemical analyses of the grain show it to contain slightly more protein and starch and a little less fat and fiber than corn. The somewhat lower feeding value seems to be due to lower digestibility rather than to any particular difference in composition.

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[1] Experiments with Kafir Corn; Bulletin 56, Kansas Agricultural Experiment Station, 1895, pp. 165–167.

[2] Digestion Experiments and Fodder Analyses; Bulletin 37, Oklahoma Agricultural Experiment Station, 1899, pp. 1–20. Summary of Digestion Experiments with Kafir; Bulletin 35, Oklahoma Agricultural Experiment Station, 1898, pp. 1–4. Digestion Trials; Bulletin 46, Oklahoma Agricultural Experiment Station, 1900, pp 1–8.

[3] Information Regarding the New Feed Law; Bulletin 95, Texas Agricultural Experiment Station, 1907, pp. 1–24. Kafir Corn and Milo Maize for Fattening Cattle; Bulletin 97, Texas Agricultural Experiment Station, 1907, pp. 1–20. Digestion Experiments; Bulletin 104, Texas Agricultural Experiment Station, 1908, pp. 1–33. Steer-Feeding Experiments; Bulletin 110, Texas Agricultural Experiment Station, 1908, pp. 1–23. Panhandle Feeds for Beef Production; an unnumbered and undated circular of 2 pages of the Texas Agricultural Experiment Station.

The grain should be carefully ground before feeding in order to get the best results. In the form of milo chops and kafir chops it is becoming a popular commercial article. Chops are made by grinding or crushing the thrashed grain more or less finely. Head chops are made by chopping or grinding coarsely the unthrashed heads, and are therefore similar to corn-and-cob meal. Head chops are not meeting with as much favor as chops because they contain considerable so-called "dirt," which is composed of the glume hairs, awns, and fragments of the glumes and branches of the heads. For this reason many grain elevators in the Plains region have been equipped with machinery for thrashing and grinding these grains. They are thus enabled to buy these crops in the head and to thrash and grind them at their leisure in order to prepare them for the market.

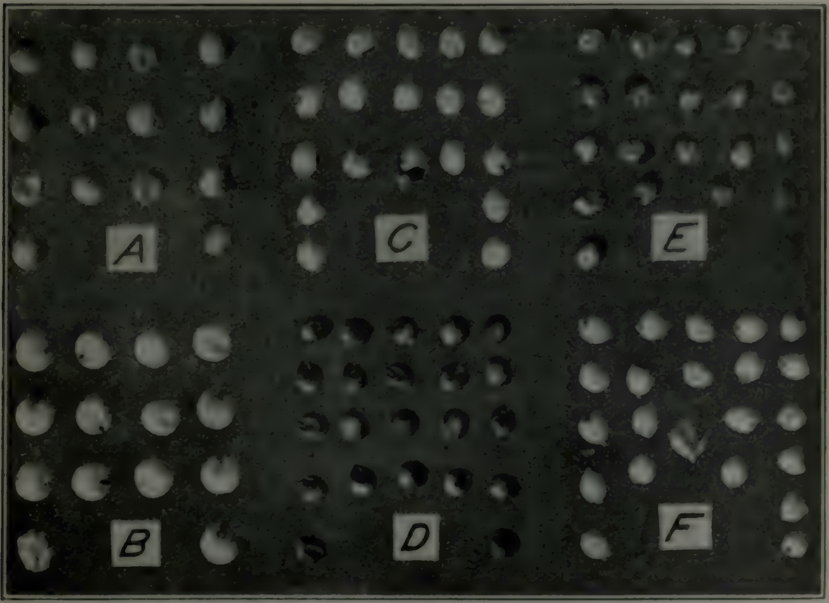

FIG. 3.—Seeds of grain sorghums: *A*, Milo; *B*, White durra; *C*, Blackhull kafir; *D*, Red kafir; *E*, Brown kowliang; *F*, Shallu. (Natural size.)

POULTRY FEED.

The grain-sorghum seeds (fig. 3) are splendidly adapted, both in size and composition, for feeding to all classes of poultry. In many parts of the country, far outside of the grain-sorghum belt, small patches of kafir, durra, or other "chicken corn" are commonly grown on the farm, simply to furnish chicken feed. There were in 1908 more than 100 firms engaged in the manufacture of over 200 brands of poultry food. Figures furnished by 33 of these firms show an annual output at that time of about 30,000 tons of these products. Approximately 10,000 tons, or one-third of this total, consisted of the seed of Blackhull kafir. This was mostly used in mixture with other grains, such as corn, wheat, screenings, etc. It is probably a conservative estimate that kafir or other grain-sorghum seed forms fully 25 per cent of the prepared poultry food sold in this country. So strong is the demand for these grains by the manufacturers of poultry food that similar varieties have been imported from as far away as India when the crop in this country was short. Considerable quantities were so imported in the winter of 1909–10, following the short crop of 1909.

HUMAN FOOD.

Meal made from the grain sorghums, ground locally, is not infrequently used in the making of batter cakes and similar articles on the farm. The general testimony is that these are delicious in quality. Some experiments are now being conducted in a small way to determine the value of the meal for more extended use. There seems little reason why, when properly milled, it should not be used in much the same manner as corn meal. Throughout Africa, India, and the other parts of southern and eastern Asia, where these crops are largely grown, they are not only commonly used as human food, but in many countries they furnish the chief article of diet.

STATISTICS OF ACREAGE, YIELD, AND VALUE.

Complete statistics of the production of these crops are not available. The national census, taken every 10 years, has not yet separated them in its schedules from other related crops. Of the five or six States which grow them largely only two gather State statistics of farm crops. These two are Kansas and Oklahoma. The figures have been gathered in Kansas since 1893, but in Oklahoma only since 1904 for kafirs and since 1905 for milo. The facts given below have been compiled and adapted from the figures published by the boards of agriculture of these two States.

TOTAL GRAIN-SORGHUM CROP IN KANSAS AND OKLAHOMA.

In Kansas the acreage of kafirs and milo has increased from about half a million acres in 1904 to nearly three-fourths of a million acres in 1909. In that State the yield is estimated in tons of fodder, and the average for the last six years has been 3 tons per acre. The average value of these crops per acre for the same period has been $10.28. Although the average yield per acre does not seem to be increasing, the average acre value is rising; for the first three years of this period it was $9.60, for the last three years it was $10.95.

The records for the present State of Oklahoma are not complete. From 1904 to 1906, inclusive, the figures are for only the old Territory of Oklahoma; for 1907 to 1909 they are for the entire new State, including the former Indian Territory. The area devoted to these crops has increased from 500,000 acres in 1907 to nearly 700,000 acres in 1909. The yield of grain during the six years from 1904 to 1909, inclusive, averaged 11.6 bushels to the acre. The average acre value of these crops during that period was $5.68. No account was taken of the value of the stalks until the year 1908. In that year the value of the kafir stalks was found to be nearly one-half as much as the value of the grain, or nearly one-third the combined value of grain and stover. In the case of the milo crop, the stalk value was exactly one-fourth the grain value or one-fifth of the combined value. It is not clear from the State reports whether the fodder and grain represent the product of the same field or whether the figures for fodder are based on fields not harvested for the grain. It has been assumed that the former was intended.

KAFIR, MILO, AND CORN CROPS IN KANSAS AND OKLAHOMA.

In 1904 there were only 7,000 acres of milo in Kansas. By 1909 this had increased to more than 100,000 acres. During this six-year period the average yield was 2½ tons per acre, the average value per ton $3.87, and the average acre value $9.52.

In the same period the acreage devoted to kafirs had increased from 500,000 to 636,000 acres, with an average yield of 3 tons per acre and an average price of $3.48 per ton. The average acre value was $10.33.

During the same period the corn acreage had increased from 6,500,000 acres to 7,750,000 acres, giving an average yield of 23.1 bushels; the average selling price was 44 cents per bushel, and the average acre value $9.83.

Owing to the reasons already stated the figures for Oklahoma can not readily be compared. However, in 1909 there were 203,000 acres of milo with an average yield during the five-year period of 13.8 bushels, an average selling price of 44 cents per bushel, and an average acre value of $6.31.

The year 1909 showed 482,000 acres of kafir, with a six-year average yield of 11 bushels, an average value of 45 cents per bushel, and an average acre value of $5.56.

There were 5,135,000 acres of corn grown in 1909. The average yield for the six years from 1904 to 1909 was 19.45 bushels, the average price 43.5 cents per bushel, and the average acre value $8.29.

The proportion of grain sorghums to corn grown in these States is steadily increasing with the settlement of the drier western portions. The average acreage of grain sorghums for the period from 1904 to 1909 in Kansas was equal to 8.7 per cent of the average corn acreage. For the year 1909 alone it had increased to 9.6 per cent in spite of an enormous increase in the corn acreage. In Oklahoma the same figures are not comparable because of the change from a small territory to a larger State. However, the average grain-sorghum acreage in the old Territory from 1904 to 1906 was equal to 25.6 per cent of the corn area. In 1907, in the new State, including both Oklahoma and Indian Territories, it was 12.5 per cent; in 1908, 12.7 per cent; and in 1909, 13.4 per cent. The sudden decrease at the beginning of the second period is due to the fact that the area comprising the former Indian Territory grows much corn and little grain sorghum.

As already pointed out, the grain sorghums are all grown most extensively in the drier areas west of the ninety-eighth meridian. In Kansas, during the period from 1907 to 1909, inclusive, about 94 per cent of the milo, about 45 per cent of the kafir, and about 25 per cent of the corn were found west of this line, which divides the State almost exactly in half. In Oklahoma about one-third of the State lies west of this line and contains 97 per cent of the milo and 79 per cent of the kafir, based on averages of five and six years, respectively.

The 46 counties in the western half of Kansas grew, in round numbers, 240,000 acres of grain sorghums in 1907, 334,000 acres in 1908, and 396,000 acres in 1909. This was an increase of 39 per cent in the grain-sorghum acreage for 1908 and of 18.6 per cent for 1909. The same counties grew 1,500,000 acres of corn in 1907, 1,750,000 acres in 1908, and 2,000,000 acres in 1909, increases of 17 and 14 per cent, respectively. The ratio of the acreage of grain sorghums to that of corn was 1 to 6.2 in 1907, 1 to 5.3 in 1908, and 1 to 5.1 in 1909. The grain-sorghum acreage was therefore equal to 16.1 per cent, 18.9 per cent, and 19.5 per cent of the corn acreage of these three years, respectively. Ten of these counties grow larger areas of grain sorghum than of corn.

In the 21 counties now comprising the western third of Oklahoma there were grown 327,000 acres of grain sorghum in 1906, 423,000 acres in 1907, 465,000 acres in 1908, and 580,000 acres in 1909, increases of 29, 10, and 25 per cent ,respectively. The ratio of grain-sorghum acreage to that of corn was 1 to 2.1 in 1906, 1 to 2.7 in 1907, 1 to 3.1 in 1908, and 1 to 3.07 in 1909. These ratios represent grain-sorghum acreages equal to 47.6 per cent, 37 per cent, 32.2 per cent, and 32.6 per cent of the corn acreages for the same years. Three or four of these counties grow more grain sorghums than corn.

SUMMARY OF THE VALUES OF GRAIN SORGHUMS AND CORN.

In Table I is given the minimum, maximum, and average value per acre of the grain-sorghum and corn crops in Kansas and Oklahoma. It will be noted that for Kansas the minimum acre value of the combined grain sorghums is not as low as the minimum for corn; that the maximum is nearly as high, and that the average acre value is higher by 45 cents an acre. In Oklahoma the facts are exactly reversed.

Two facts must be kept in mind while comparing these figures. One is that for Kansas the yields and values of grain sorghums are based on tons per acre and thus include the value of both grain and stover. The yields and values of corn, on the contrary, are based on bushels of grain per acre. If the value of the corn stover were also included, the average acre value for corn would probably somewhat exceed that of the grain sorghums. The difference, however, would probably not be as large as in the case of the Oklahoma figures. The other fact is that the grain sorghums are most largely grown in the western parts of these States. Here the shorter seasons and lower rainfall tend to decrease the yields of all crops. This puts the sorghums at a disadvantage in a comparison with corn, which is most extensively grown in the lower and more humid portions.

TABLE I.—*Summary of value of grain sorghums and corn in Kansas and Oklahoma.*

State and crop.	Number of years averaged.	Yield per acre.	Price.	Acre value.				
				Minimum.		Maximum.		Average for period.
				Year.	Value.	Year.	Value.	
Kansas:		*Tons.*	*Per ton.*					
Kafir	6	2.99	$3.48	1906	$9.18	1909	$11.21	$10.33
Milo	6	2.53	3.87	1906	8.31	1907	10.61	9.52
Total grain sorghums	6	2.95	3.48	1906	9.16	1907	11.10	10.28
		Bushels.	*Per bu.*					
Corn	6	33.1	.44	1904	7.81	1908	11.71	9.83
Oklahoma:								
Kafir	6	11.0	.45	1904	3.92	1907	7.77	5.98
Milo	5	13.8	.44	1909	2.55	1907	8.64	6.31
Total grain sorghums	6	11.6	.45	1904	3.92	1907	8.00	5.68
Corn	6	19.4	.43	1904	6.24	1906	11.21	8.29

IMPROVING THE GRAIN SORGHUMS.

In general there are two ways by which the grain-sorghum crops can be made of greater value to the grower. The first is by improving the varieties; the second, by finding more rapid and economical methods of harvesting. Improved varieties can be obtained through selection of present sorts and by bettering the methods of growing them. More rapid and economical harvesting will come about either through adapting the crops (fig. 4) to present machinery or through the invention of new machines, or both.

There are five principal ways in which improvement may be made: (1) Increased drought resistance, (2) increased earliness, (3) dwarfer stature, (4) greater productiveness, and (5) increased machine harvesting.

DROUGHT RESISTANCE.

The grain sorghums are most useful in regions where moisture is often the controlling factor in crop production. Much good should therefore be accomplished by increasing their drought resistance, especially in the areas of lighter rainfall.

No one knows exactly what drought resistance is. It is probable that what we call drought resistance is the effect of several different factors. The most important of these factors are probably (1) increased ability to prevent the loss of water by transpiration, (2) increased development of the root system, and (3) a possible increase in power to extract water from a dry soil.

Differences in the power to control transpiration are well-known and readily observed facts. By transpiration is meant the passing of water from the tissues of the plant into the air. In the processes of their growth all plants are constantly absorbing water from the soil through their rootlets and allowing certain quantities of this moisture to pass out into the air through minute pores, called stomata. This is done in much the same manner as water escapes through the animal skin in the form of perspiration. In times of drought it is important that the plant lose as little as possible of its water supply in this way. The plant best fitted to prevent transpiration is thus the most drought resistant. In cacti, for instance, this ability is highly perfected. Corn is much less drought resistant than the members of the various groups of sorghums. Corn is in danger when the leaves begin to curl, but sorghums often remain in this condition for a long time without permanent injury.

The size and character of the root system is probably a strong factor in drought resistance. The larger the root system in proportion to the plant, the better it can supply moisture. The wider and deeper its penetration, the larger the area of soil from which it draws moisture in time of drought. A deeply rooting plant may be able to secure water when shallow root systems lie wholly in dry soil. This is entirely apart from possible differences in ability to extract moisture from a given unit of soil. Such differences may exist, but the idea is only a theory as yet. Unfortunately, the character of the root system can not be observed while making selections.

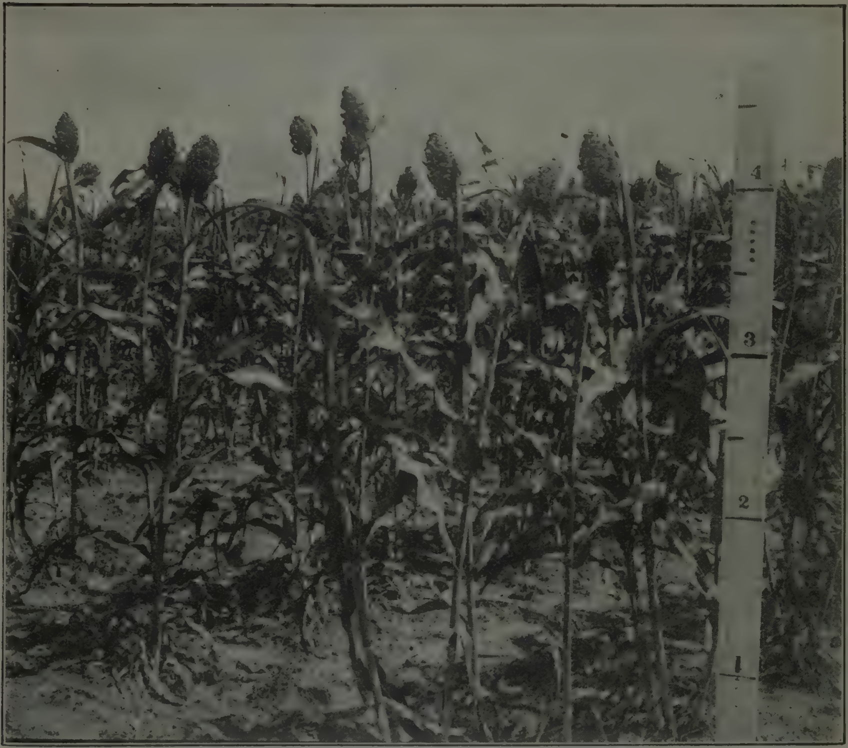

FIG. 4.—Plat of milo, selected for erect heads and low stature.

Selections for drought resistance will naturally be made on conditions that can be seen with the eye. These are likely to be the results of a combination of means for actually resisting drought and for evading drought. Dwarfness, earliness, and thin stands are means or conditions for drought evasion. By making allowance for them, when present, one can select for actual drought resistance. This will be done by using those plants which give best results under drought conditions when they are neither dwarfer nor earlier nor more thinly planted than their neighbors.

EARLINESS.

There are two principal reasons for desiring early varieties. The first is to extend the range of grain sorghums into dry regions having a short growing season. The second is to secure the fullest possible benefit from the seasonal rainfall, which comes largely during the early summer months in parts of the grain-sorghum belt. The second reason is thus connected with the problem of drought resistance, though, as pointed out, earliness is a means of drought evasion, not of resistance. Improvement in earliness will need to be continued for a long time if varieties are to be perfected for the needs of all the dry-farming regions.

EARLY VARIETIES.

The milos are much earlier varieties than the kafirs and are very promising material on which to work. In the Panhandle of Texas, at elevations of 3,000 to 4,000 feet, they now mature in 90 to 100 days when sown May 15 to 20. At present they are grown successfully up to an altitude of between 4,000 and 5,000 feet in Texas, New Mexico, and Colorado. At higher elevations the growing season is shortened to such an extent that the present varieties of milo do not mature. At lower elevations their present range extends northward into southwestern Nebraska. In northern Nebraska, the Dakotas, Montana, and Idaho the increasing latitude and shorter growing season prevent their successful maturing. It seems certain, also, that the soil, especially at night, is too cool to permit vigorous growth, thus retarding the maturing of the plant even where the season is otherwise long enough.

The durra group contains some very early varieties. The only one well known in this country is the common White durra (fig. 5), which has been called "White Egyptian corn," "Rice corn," and "Jerusalem corn" in the successive periods of its popularity. It matures as early as or slightly earlier than the milos. White durra apparently possesses true drought resistance also and is a good yielder, but shatters quite badly and is not liked for that reason and some others. Some hybrids of this variety with Blackhull kafir have been under selection for three years and give promise of being valuable.

The kafirs usually require about three weeks longer than milo to mature under the same conditions. An early strain of Blackhull kafir developed by the writer, through selection, matures about two weeks earlier than the ordinary kafirs and only three to five days later than milo. The old-fashioned White kafir with white hulls, now rarely found in cultivation, was a semi-early sort and would make good selection stock if its heads were free from the boot and if it was not so readily attacked by diseases. Red kafir, which is normally a week or more earlier than the Blackhull in the low plains, seems to become proportionally later as it is carried westward to higher elevations. At the Amarillo Experiment Farm it has been consistently later than the Blackhull variety during a period of several years.

The group of kowliangs from northern China and Manchuria contains some varieties (fig. 6) which are naturally very early, especially among the brown-seeded sorts. Three of these (Grain Investigations Nos. 171, 261, and 328) have matured in 80 to 90 days, thus proving earlier than the milos in the Panhandle of Texas. Some promising selections from them have been made in northern Colorado, in Nebraska, and in South Dakota. Coming, as they do, from latitude 40° or higher, they may prove able to germinate and grow at lower temperatures than the groups which have come from more southern latitudes.

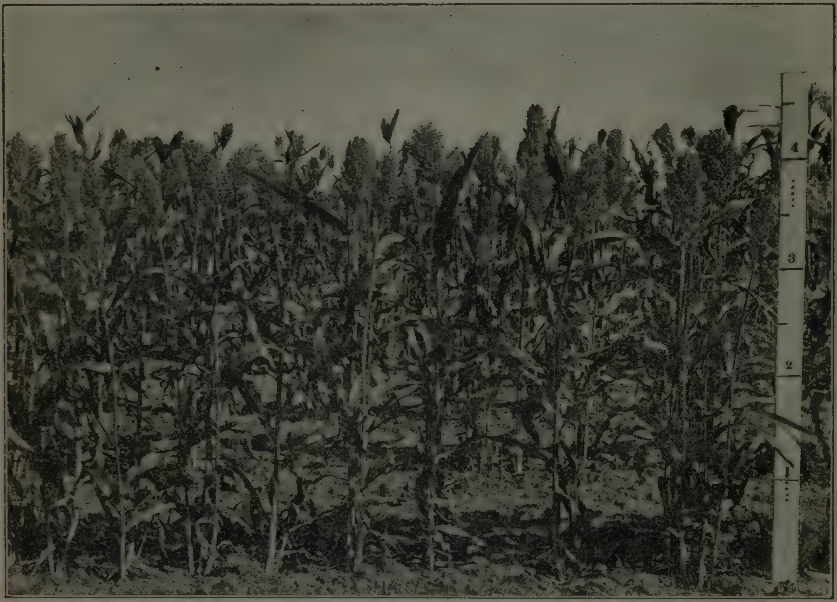

FIG. 5.—Plat of White durra with 100 per cent of the heads erect.

EARLY CROPS AND EARLY SEASONAL RAINFALL.

The effect of earliness in permitting drought evasion is very important. Consider two plants, one earlier than the other, but otherwise similar in all respects. The earlier plant, having a shorter growing period, not only uses less water, but uses it earlier in the season. This is of especial importance in those parts of the semiarid country where much of the seasonal rainfall occurs in April, May, and June. The earlier plant might be able to mature its crop of seed on the summer rainfall. On the other hand, the later plant might be crippled at a critical stage by the exhaustion of the soil moisture during dry weather in August. It is fairly certain that in much of the Plains region the greater part of the soil moisture in a field is not used by the growing plants, but is lost by evaporation under the average tillage conditions.

Milos are earlier than kafirs, but are not known to be more truly drought resistant. At Amarillo, Tex., under conditions of severe drought from the middle of July until October, 1909, the milos yielded on the average 8.3 bushels and the kafirs only 5.5 bushels to the acre. In each crop the figures are the average of between 20 and 30 plats and show that the difference was really in the earliness (and perhaps dwarfness, also) of the milos as compared with the kafirs, the yields in normal years being about equal.

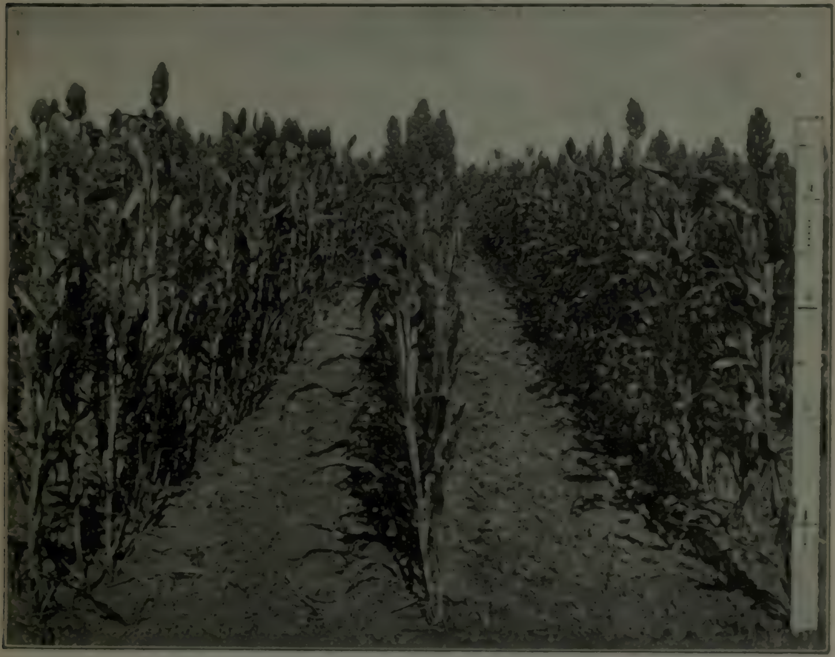

FIG. 6.—Plat of selected Brown kowliang (G. I. No. 171).

The season of 1910 was still drier, only 10 inches of rain falling at Amarillo from January to October, inclusive. Better yields were obtained than in 1909, however, because the average stands were much thinner. Under these conditions 32 plats of milo and Dwarf milo yielded an average of 17.9 bushels per acre, while 22 plats of ordinary Blackhull and Red kafirs yielded only 3.7 bushels. The difference in average yield is 14.2 bushels. Even if we admit that half of this difference is due to the dwarfer growth of the milos compared with the standard kafirs, we still have a gain of 7.1 bushels due to earliness alone.

The relative values of earliness and dwarfness are further indicated in results obtained from three strains of Blackhull kafir. The writer has produced by selection an early strain of the Blackhull kafir which is nearly two weeks earlier than the ordinary strains, although of the same height. In 1908, a favorable season, it yielded about 10 per cent less than the average of the ordinary Blackhull varieties. In 1909, however, it yielded 10.7 bushels to the acre, while 20 ordinary strains averaged only 5 bushels and the best of them yielded only 10.9 bushels. In 1910, under the conditions described it produced 7.57 bushels compared with 2.95 bushels from 15 standard plats.

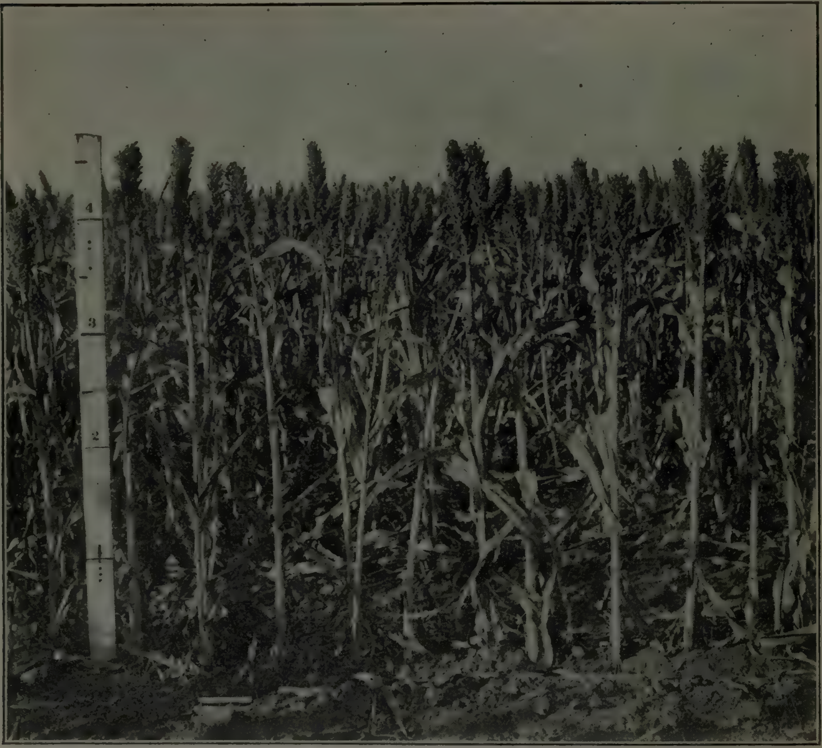

FIG. 7.—Plat of dwarf and early Blackhull kafir (G. I. No. 340).

Another early strain, which is also dwarf, growing to a height of about 4 feet (fig. 7), yielded in 1908 about 4.5 bushels less than the average of the ordinary taller and later strains. In 1909 it yielded 14.4 bushels compared with 10.7 bushels from the tall but early strain and an average of only 5 bushels from the ordinary taller and later strains. In 1910 it yielded 9.28 bushels, while, as noted above, the tall early strain produced 7.57 bushels and the ordinary strains only 2.95 bushels per acre. These figures indicate that in 1909 about 40 per cent and in 1910 about 27 per cent of its increased yields were due to its dwarfness and 60 per cent and 73 per cent, respectively to its extra earliness.

SELECTING FOR EARLINESS.

Earliness can be developed only by continued selection. Such selections can be made either at heading time or at the time of ripening, but are preferably the results of records made at both periods. When the field or seed plat of the variety begins to head, a number of the earliest heads, which are otherwise suitable for selection, should be marked by means of tags on which is recorded the date of heading. When the heads on these selected stalks begin to show the characteristic colors and texture of the hard-dough or ripening stage, the date of ripening should be added to the tags. Other things being equal, those heads for which the shortest time has elapsed between heading and ripening are to be considered the earliest. These should be carefully saved separately and used for continuing the work another season.

In dry regions where the amount of moisture in the soil commonly controls the growth of the crop, the plants at the ends and sides of a field are often the first to produce heads, especially in dry seasons. This is because the outside plants have a larger area from which to draw moisture, or because run-off water often collects at the edges of fields and provides extra moisture. These early heads will be the first to ripen, but it does not follow that these plants are naturally earlier than the rest of the field.

DWARF STATURE.

For the grain-sorghum grower a dwarf variety has two advantages over the taller strains. It requires less water and can be harvested with a grain header.

The larger the plant the more water it requires and the more it is likely to lose by transpiration. A small plant which can produce as much grain as a large plant will thus have a real advantage in a dry season. This is not true drought resistance, but merely a lower water requirement which permits drought evasion.

As previously noted, the year 1909 was marked by severe drought during July, August, and September in the southern half of the Great Plains. At the Amarillo Experiment Farm, in Texas, 17 plats of milo gave an average yield of 6.8 bushels and 10 plats of dwarf milo an average yield of 11 bushels to the acre. The best plat of milo yielded at the rate of only 16.5 bushels, though in a low piece of ground, while the best dwarf milo yielded 23.2 bushels per acre. In 1910 there was not as much difference. Eight plats of milo yielded an average of 16.2 bushels per acre, and 7 plats of dwarf milo yielded an average of 19.6 bushels. The advantage in favor of the dwarf variety seemed to be largely due to the smaller size of the plants and the consequent lower water requirement.

The case of the dwarf and also early strain of the Blackhull kafir (fig. 7) has already been noted under the discussion of earliness. How much of its increased yield was due to dwarfness and how much to earlier maturity can not be certainly known. Apparently about one-third was due to its dwarfness and two-thirds to its earliness.

The production of dwarf varieties has made possible the use of the grain header in harvesting the crop. A few ingenious farmers have succeeded in raising their headers on timbers until they will cut, with fair satisfaction, the ordinary tall varieties, but it is not likely to become a general practice. In case a successful row header is invented it is more likely to work well on low varieties than tall ones, especially in windy regions.

Selecting for dwarf stature raises the question of the ability of a plant to produce as large seed yields after the stalk and leaves have been reduced in size. How far can reduction in the size and height of stems be carried without reducing the total leaf area? How far can reduction of leaf area be carried without reducing grain production? These questions can not be answered except by long-continued investigations. The limits of profitable reduction in size will vary with climatic conditions of different regions. While these limits are not yet fully known for any region, there is fair proof that the standard varieties of the central Plains region can be much reduced without passing the lower limit. The Dwarf milo (fig. 8) and Dwarf kafir are only 3 to 4 feet in height under conditions that make the normal crop 5 to 6 feet in height. The Dwarf milos outyield the standard milos even in favorable seasons. The White durra, which is low, yields as much as the kafirs, which are of medium height or taller. The Dwarf kafir, although recently produced, seems likely to hold its own in a series of years. An extra-dwarf Brown kowliang has been obtained in China. It grows to a height of about 2 feet, but, like most newly introduced sorghums, does not show high yielding power.

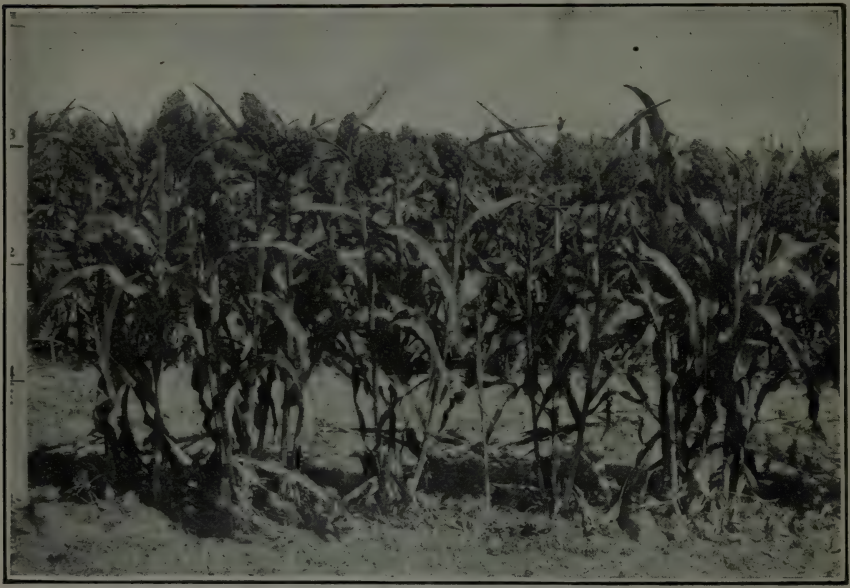

FIG. 8.—Plat of select Dwarf milo.

These crops have originated in subtropical lands and are commonly inclined to large growth. While they have been used chiefly for grain production in their native homes, it has been by more or less primitive peoples, and the returns have not been large. Since coming to this country most of the standard varieties have been reduced in size and at the same time increased in yielding power. The limit of profitable dwarfness has probably not been reached; it certainly has not been passed.

PRODUCTIVENESS.

The two keys to increased grain yields are better varieties and better methods of growing them. Better varieties mean pure and smut-free crops, with better filled and perhaps larger heads, erect and fully exserted from the boot, borne on stalks with fewer suckers and no branches. Better methods relate to proper and even spacing of stalks in the row and to thorough cultivation of the growing crop. They also include proper rotations and suitable tillage of the land when not in crop. Selections for better yields may naturally be continued as long as the crop is grown. No one may say what returns will finally be obtained. We may reasonably hope, by continued effort, to increase greatly the present average yields.

PURE VARIETIES.

Extended travel and observation in the grain-sorghum belt show that many of the fields of different kafir and milo varieties are not pure. The same is true of the fields of sorgos or sweet sorghums and of broom corn. This condition comes from two causes, mixtures and hybrids. Usually both are present, because mixtures quickly result in hybrids.

The advantages of pure crops are many and easily seen. Pure varieties are most likely to be uniform in height and in time of ripening, and hence are easy to harvest. The grain is of much greater value for seed purposes and also obtains a higher grade and commands a better price on the grain market. It is also better as a feeding grain, because more uniform in quality.

Mixtures readily result from carelessness in cleaning empty bags, bins, wagons, and separators, or in storing the seed. Most of the mixing from these causes may be easily prevented. The presence of other varieties as volunteer crops in the fields is also a common cause of mixtures and one not so easily controlled. Early Amber sorgo and related strains are very common and troublesome volunteer crops in western Kansas and Oklahoma. The damage done by these mixtures of varieties can be largely remedied by roguing the fields; that is, removing by hand all plants not true to the variety grown. Where not possible to rogue an entire field, a part may be cleaned and the seed saved from that portion.

Crossing or hybridizing is more common in the sorghums than in most other farm crops. This is because they are all open fertilized; that is, intended to be cross fertilized by means of the wind. The three stamens (pollen-bearing or male part of the flower) and two pistils (pollen-receiving or female part of the flower) all appear outside the glumes or hulls of the flower in the early morning. The anthers or pollen sacs open at the end, and the pollen grains are quickly emptied into the air as the anthers swing in the wind. The pollen is quite as likely to be carried on the breeze to the flower on some other plant as it is to fall upon the pistils projecting from the flowers on the same plant. The ease with which such crossing occurs is increased because these crops are most largely grown in regions of fairly constant winds and because their greater height enables the wind to carry the pollen farther than in the case of lower crops.

Crossing is likely to occur whenever two varieties are growing near each other if they are in flower at about the same time; hence, whenever mixtures of different varieties are found in a field, hybrids are almost certain to be formed and to appear in the crop the following year. In the grain-sorghum belt many of these are caused by the presence of Early Amber and other volunteer sorghum varieties in the fields of nearly all farms. Hybrids also result from planting the fields of different varieties too near together. Just how far apart the fields should be to insure safety from hybridizing is an open question. In the Great Plains area the prevailing winds are from the south and the alternating winds usually from the north. Crossing, therefore, takes place at greater distances in a north and south line than in an east and west line. Where two fields lie north and south from each other, a distance of 8 or 10 rods would probably be required, and 15 or 20 rods would be preferable. Where the fields lie east and west from each other, the crops would be fairly safe from crossing at shorter distances than those stated.

SMUT-FREE VARIETIES.

There are two kinds of smut affecting sorghums, head smut and kernel, or grain, smut. In the former the young head becomes a black mass of smut spores, inclosed at first in a grayish covering or membrane. In the kernel smut the seed is the only part visibly affected. The head looks much as usual except that in the case of white-seeded varieties it is much darker in appearance. The seeds are replaced by longer, gray smut kernels, full of black spores. These smuts occur on all kinds of sorghums except milos. Neither smut has ever been found on the varieties of the milo group.

The head smut is not very common, which is fortunate, because no means of controlling it is yet known. The kernel smut is quite common, and often completely destroys from 2 to 10 per cent of the heads in a field, reducing the yields of grain in the same proportion. It can easily be controlled by the modified hot-water treatment or by the use of formalin.[1]

BETTER YIELDING VARIETIES.

Better yielding varieties may come originally from an experiment station or other source, or they may be produced by the farmer himself from his own fields. In either case the grower must continue the selection from year to year. In its simplest form this will mean the selecting of stalks of desirable size and habit, bearing large and well-shaped heads (figs. 9 and 10), well loaded with plump grains. This requires, of course, that the work of selection be done in the field.

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[1] Full directions for using these treatments are given in Circular 8, revised, Bureau of Plant Industry, U. S. Dept. of Agriculture, entitled "The Smuts of Sorghum," which may be obtained free on application to the Secretary of Agriculture.

Heads selected in the bin or crib tell little of the stalk on which they grew. The work should be done before harvesting begins and a sufficient quantity selected to furnish plenty of seed for the farm crop of the next year. Where early selection of seed has been neglected the selections may still be made during harvest, if harvesting is done by hand. A small box, fastened to the near side of the wagon bed, will serve to receive the selected heads. Careful selecting is not likely to be done, however, in the hurry of harvest. Where machine heading is practiced this method is, of course, not possible.

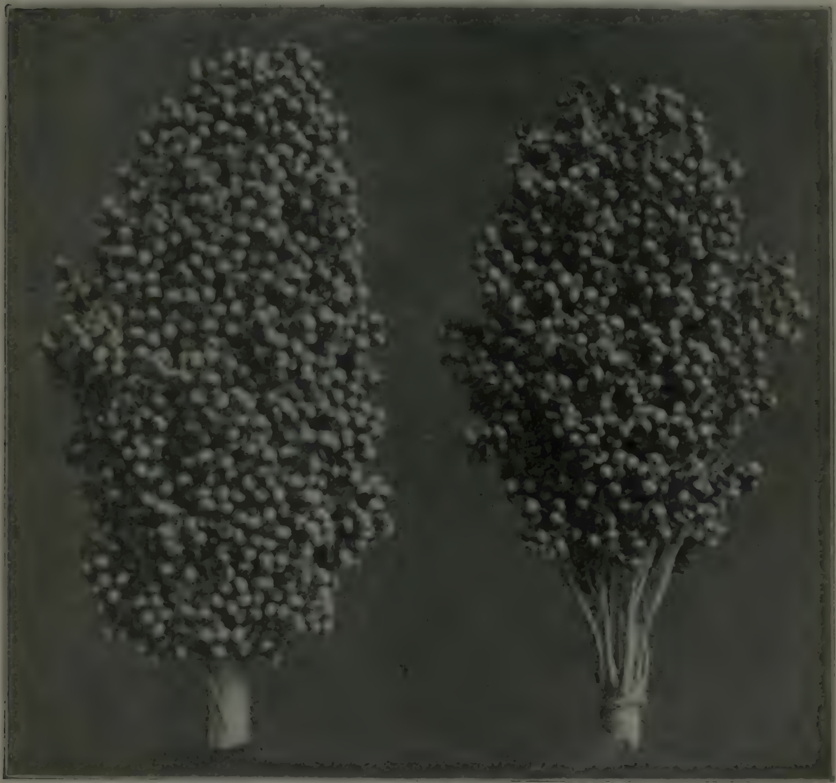

FIG. 9.—Two heads of milo showing desirable and undesirable forms.

The selected heads may be hung up in a dry place or laid in thin layers on shelves and thrashed in the spring. If they are thrashed in the fall, the seed should be carefully stored in a cool room, and preferably in bags rather than in bins. There is much danger of lowering or destroying its vitality if it is allowed to heat.

Desirable Forms of Heads.

Well-filled heads.—It is important that the heads be well filled at the butts and tips, as in the case of corn ears. Less attention has been given to this matter than it deserves. Figure 9 shows desirable and undesirable forms of milo heads, and figure 10 shows desirable heads of Blackhull kafir. Milo may be taken as representing durras also, while the kafir may be regarded as the proper shape for kowliangs as well. The poorer head contains less grain and is therefore less productive. It also contains a larger proportion of fiber and hence is less valuable as a feeding ration.

The heads selected should have shorter branches at the butt than in the rest of the head. These lower branches should be loaded with seed down to the point where they join the rachis or central stalk of the head. Long basal branches are likely to droop and finally break away under the combined stress of weight and wind.

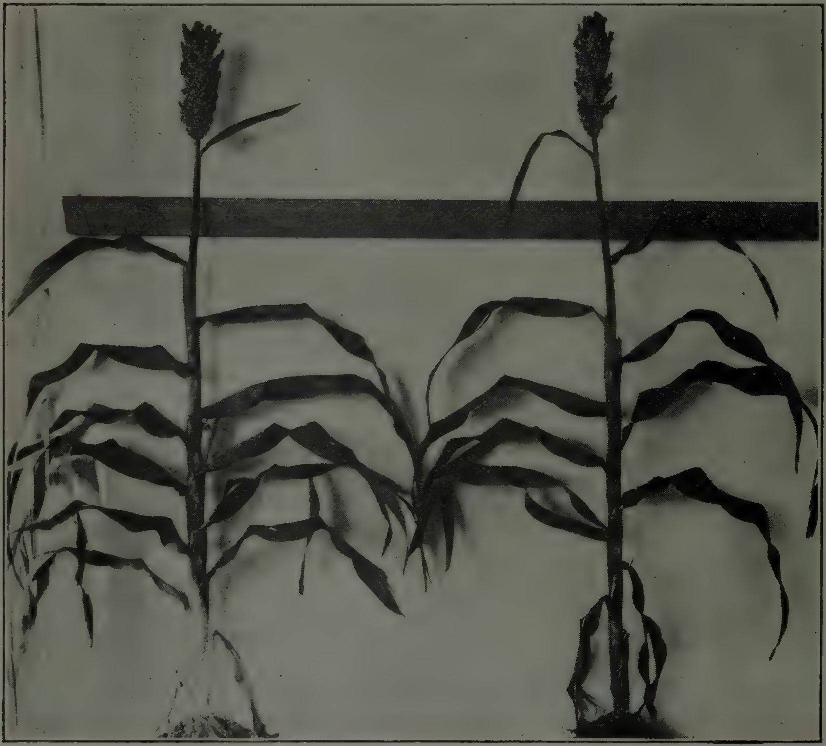

FIG. 10.—Two plants of Blackhull kafir, 5½ feet high, selected for high yielding power.

Fully exserted heads.—It is also important that the head be fully exserted from the boot, or upper leaf sheath. No seed is produced on the part not exserted, which often becomes moldy or rotten if wet weather prevails. Corn ear-worms (*Heliothis obsoleta*) and false army worms (*Laphygma frugiperda*) breed in such places and add to the injury. When these heads with spoiled butts are piled with others they are likely to cause damage to the whole heap. Varieties in which the heads are not fully exserted are also more difficult to harvest by hand or machine.

The main agricultural difference between White kafir and Blackhull kafir is that the heads of White kafir never become fully exserted from the boot. White kafir was the first kafir variety to come into general cultivation in this country, but it has since been almost wholly discarded, largely for this reason. Blackhull kafir, the present popular variety, bears the heads normally entirely free from the boot (fig. 10).

Large heads. In selecting for large heads the proportionate size of the stalks must always be considered. Not the largest head alone, but the largest possible head on the smallest stalk is the most desirable selection. The grain sorghums are for use where limited rainfall is the principal controlling factor in grain production. Larger plants use and transpire more water than smaller ones. Selection should be made where the stand is uniform and fairly thick, and should include the largest and best heads produced under such conditions. They should not be made from the outer row of the field or plat, or from places where the stand is thin, even though the larger heads are found in such places. From 6 to 7 inches of row for each stalk is considered the proper spacing for milos and 9 to 10 inches for kafirs in the higher plains.

Average weight of heads.—The average weight of heads varies with the stand and seasonal conditions. Close spacing of stalks in the row or an unfavorable growing season reduces the size of the heads, even if they are well filled. Wide spacing and favorable conditions cause larger and heavier heads. Under average field conditions the heads of milo and Dwarf milo weigh from 3 to 4 ounces and those of durra varieties about 3 ounces each. In the kafir group the heads are normally much heavier, weighing from 4 to 6 ounces, while kowliang heads vary between 3 and 4 ounces each.

Percentage of Grain in Total Crop.[1]

The percentage of grain in the total crop varies greatly with the character of the season in which the crop is grown and with the stand of stalks. Some experiments indicate that under ordinary conditions milo and Dwarf milo will produce from 35 to 40 per cent of their total weight in the form of grain. In Blackhull kafir, and probably Red kafir also, the average will be about 25 per cent, on account of the heavy stalks and leaves of the kafirs. For the kowliangs the proportion will be about the same as in milos. One plat of milo at the Dalhart Experiment Farm, Texas, in 1908 yielded 47.2 per cent of its weight in grain. Three plats yielded above 40 per cent. On the other hand, in seasons of drought or other unfavorable conditions the percentages of grain may fall to one-half or less of the averages given above.

Freedom from Suckers and Branches.

All sorghums apparently have the habit of producing both suckers and branches. There is, however, considerable difference among the groups and varieties in this regard. Suckers seem to be produced normally, branches only under somewhat exceptional conditions. They will be discussed separately.

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[1] See Bulletin 203, Bureau of Plant Industry, U. S. Dept. of Agriculture, entitled "The importance and improvement of the grain sorghums," by Carleton R. Ball, for a discussion of tabulated results.

Suckers.—These are produced from the closely crowded lower nodes or joints of the stem, just at the surface of the ground. They appear in some cases almost as early as the main stalk itself and in other cases not until the main stalk is well grown or even after it has begun to mature its seed. They may vary in number from 1 to 10 or 15, according to the habit of the plant or to the particular environmental conditions, such as abundance of food, moisture, etc. Though their heads are usually smaller, suckers differ from the main stalk chiefly in height and earliness. They are usually rather lower and almost always later in maturing, often very much so. Where the latter part of a season is more favorable than the earlier, suckers often grow taller than the main stalk. Their difference in stature is objectionable only in harvesting, but their late ripening is a more serious matter.

The value of suckers in grain-sorghum crops is still a debated question. Many of the advertisements offering the seed of these crops dwell at length on their power to produce several stalks from one seed. Considering the cheapness of the seed of grain sorghums and the exceedingly small quantity (2 to 4 pounds) needed to plant an acre, the grower can well afford to require only a single stalk from a single seed. In a forage crop, where abundance of leaves is wanted, suckers may be very desirable, but in a grain crop requiring little seed the weight of evidence is against them. Their existence may be partly justified by their help in making a fuller crop where a thin stand occurs. This is largely offset by their somewhat later maturing. It is a question whether the seed produced really pays for the food and moisture used.

Selections should then be made with the object of entirely removing suckers. This can best be done by selecting heads from stalks which produce none. In case the crop on which selection is begun does not contain any stalks wholly without suckers, the selection should be made from stalks which have only a single sucker or in which the suckers are very small and appear very late in the season. In this way the tendency to produce them will gradually be overcome. Closer planting in the drills will also have this effect. The combined effect of these two methods will materially reduce the numbers.

Branches.—The stems of all sorghums, like those of corn, are made up of alternate joints, called nodes, and elongated sections of nearly round stem called internodes, meaning literally "between the nodes." The peduncle is the rather long section of the stem which grows from the uppermost node and bears the main head. A leaf arises at each node. The lower part of each leaf is called the sheath and is a collar which tightly incloses the internode for some distance above the joint or node from which it grows. A little bud is borne at every node except the uppermost, which bears the main peduncle instead. These buds lie snugly in a little furrow in the internode, with the leaf sheath wrapping them like an overcoat. When conditions are favorable, these buds develop into branches.

Branches are most likely to be produced when the weather remains warm and moisture is abundant late in the season. The uppermost bud develops first, the young branch forcing its way out at the top of the leaf sheath or by splitting the back of the sheath. It then rapidly elongates, putting out leaves and finally a terminal seed head.

It thus becomes a miniature stalk, growing on the parent stalk and exactly like it in all respects except size. Meantime the buds at the successively lower nodes have been making similar growth. If the season is long enough and the moisture sufficiently abundant, all these developing buds will become fruit-bearing stalks. In extreme cases the lateral buds on the oldest or uppermost branches will themselves develop into branches. This compound branching could go on indefinitely if permitted by seasonal conditions.

The heads on these branches are much smaller and less productive than those on the main stalk. They are also much later in maturing. Advertisements which state that a single stalk produces from four to ten large heads are wholly misleading. The branches themselves, arising first from the upper nodes, make the plant top-heavy and likely to lodge. The presence of branches interferes with the harvesting of the grain. It often delays the maturing of the main head. Branches also use water that should remain in the ground for the use of the next crop, without making any adequate return. They are therefore wholly objectionable and should be prevented by selection and proper planting wherever they tend to occur

BETTER METHODS OF PRODUCTION.

Only methods of planting and the proper cultivation of the crop will be treated here. Rotations and general tillage to conserve moisture have their influence on crop improvement. In a new country, however, strict rotation systems can not be followed, and the general methods of dry farming need not be given in this paper. The principles are two: (1) Till so as to absorb the rainfall and (2) till so as to prevent evaporation. This subject has been fully treated elsewhere.[1]

Proper stand or row space.—The whole question of the proper stand or row space for the different varieties under different conditions of soil and moisture is one of which little is yet known It is not the plant having the largest head which makes the biggest acre yield, but the plant which can produce the largest head while growing in the smallest possible row space.

The results of four years' experiments at the Amarillo Experiment Farm, Amarillo, Tex., indicate that in general the kowliangs yield best with a stand of 1 stalk in each 5 or 6 inches of row; the milos and durras with 1 stalk in each 7 or 8 inches of row; and the kafirs with 1 stalk to each 9 or 10 inches of row In all cases the rows are 3½ feet apart, and as far as possible the seeds are dropped singly in the rows (fig. 11). Under these conditions improved varieties in each of these three distinct groups give approximately the same yields. The Amarillo Experiment Farm has an elevation of 3,600 feet and an average annual rainfall of 22 inches, the larger part of which comes during the growing season. Further investigations, continuing the experiments through a longer period of years, may discover that better average yields will be produced at other spacings than those noted above.

It is probable that at other locations better results will be secured at other rates of planting than those given for Amarillo The rate will vary with different elevations, different amounts of annual rainfall or a different proportion of it during the growing season, and with differences in the character of the soil.

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[1] See Farmers' Bulletin 266, entitled "Management of Soils to Conserve Moisture," which will be sent free on application to the Secretary of Agriculture, Washington, D. C., or to any Member of Congress

Drills or hills.—Another important question which has not yet been made the subject of experiment to any extent is the comparative value of planting in drills and in hills. For instance, 1 stalk every 6 inches in the row, or 2 stalks in a hill every foot, or 3 stalks in hills 18 inches apart, or 4 stalks in a hill and the hills 2 feet apart would all give the same number of stalks per acre. Would they give the same results in bushels of grain per acre? The answer is not known. All the evidence at hand indicates that the advantage is in favor of a single stalk in a place. Experiments with corn seem to show that where from 3 to 5 kernels are planted in a hill better results are secured when the kernels are scattered a few inches apart instead of being dropped in a bunch.

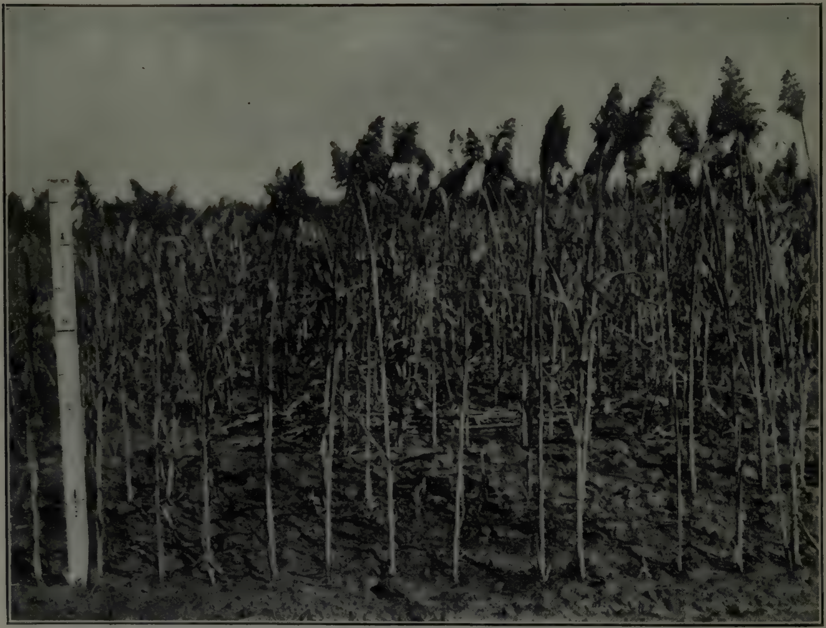

FIG. 11.—Plat of Brown kowliang, showing stalks singly and evenly spaced in the row.

Aside from the immediate question of yields, however, there are other reasons for preferring planting in drills rather than in hills. These reasons are connected with the production of suckers and pendent heads. Observations indicate that the fewest suckers and pendent heads to the stalk are produced where the stalks stand singly. Whether this be true or not, it is certain that where the stalks stand one in a place it is much more easy to determine whether suckers are produced and to take steps to get rid of them by selection.

Planter plates.—The difficulty of securing proper rates of planting is partly due to an idea persisting in the minds of growers and partly to lack of suitable plates. When the former is corrected, the latter can be easily obtained. The first sorghums extensively cultivated in this country were the sorgos, which are forage crops and as such are planted thickly. The other leading groups, the milos and kafirs, were also first regarded as forage plants and sown quite thickly. Corn planters were equipped with "cane" plates which dropped 10 to 25 seeds in a foot of drill. In this way the idea of thick seeding for sorghums became firmly fixed in the minds of growers.

The value of the milos, kafirs, and durras as grain producers was only gradually recognized. The necessity of planting thinly where high grain yields were desired was realized even more slowly. Though this necessity is now being seen by the great body of grain-sorghum growers, there is not yet knowledge and agreement as to the proper rates of planting. These vary with different conditions and must be made the subject of extensive experiments. Meantime the manufacturers of planters, though recognizing the demand for different plates, have had little data on which to create a suitable supply.

So far as the size of the seeds is concerned, probably only two sets of plates will be necessary in order to drop a single seed at a time of any variety. The two sets will have the holes of different sizes and perhaps of slightly different shapes also. Milos and durras have rather large seeds, more or less round in outline. Kafirs and kowliangs have smaller and more nearly oval seeds.

Having these two sets of plates, certain variations in the rate of planting will be necessary in order to space properly the seeds of different varieties in the drill. For instance, the seeds of kafirs and kowliangs will drop singly through the same hole, but the kafirs should be planted 10 inches apart and the kowliangs only 5 or 6 inches. This variation in rate is secured in two ways: (1) By the adjustment on the planter which changes the speed of the plate and (2) by using plates drilled with different numbers of holes. Where plates with the proper number of holes are not purchasable, blank plates can be secured and drilled by a blacksmith. Care should be taken that the holes are countersunk on the lower side of the plate so that seeds will not become wedged in them.

ADAPTABILITY TO MACHINE HANDLING.

More than ever is it true that the demand is strong for crops which may be handled readily and profitably by machinery at every stage in their production. This has long been true of the small-grain crops. Corn and cotton are examples, however, of two great staple crops which must still be gathered by hand. However, many and varied efforts are being made to produce machines which will gather the ears of corn and the lint-covered seeds of the cotton.

If the grain sorghums are to become staple crops on a large scale they must be adapted to machine handling. In the early years of the cultivation of milo and kafir as important crops, there were two methods of harvesting in vogue where seed was desired. The first was to cut the crop, stalk and all, with the corn binder and cure it in the shock.

The heads were then cut from the bundles with a knife, saw, or hatchet. The second method was to cut the heads by hand in the field. This was done with a knife and the heads were thrown into a wagon body, like ears of corn. Both these methods are in common practice to-day.

HEADERS.

Some years ago there was invented a header designed for use in heading kafir. Though still in use to some extent, it has never been a popular or widely used machine. It is rather heavy, not running upon its own gear, but attached instead to the side of the wagon box. It is heavy and hard to handle, destructive to the wagon bed, and not susceptible to quick and wide adjustments. Moreover, it heads but a single row at a time and is rather expensive, considering all these points. It can not be used on milo because of the large number of pendent heads, or on Dwarf milo because of its low growth. In recent years many attempts have been made to invent a satisfactory row header which would be free from the objectionable features mentioned. So far these efforts have not been successful, though one of the machines gives considerable promise.

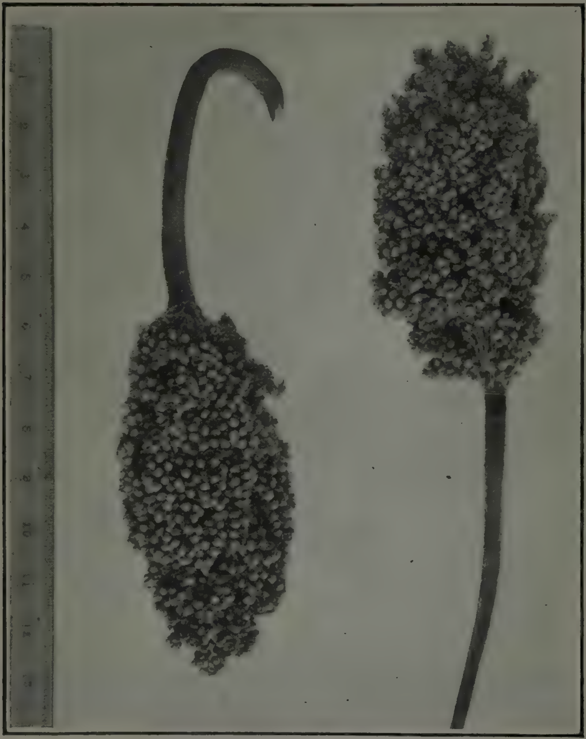
FIG. 12.—Milo heads; one pendent, one erect.

Since the introduction of Dwarf milo it has been found possible to harvest it rapidly and satisfactorily by means of the ordinary grain header. The standard milo and the kafirs are too tall for easy handling with this machine. A few ingenious farmers have, however, contrived to raise their headers on planks to a point where they will gather these taller crops with a fair degree of satisfaction. One great advantage of the grain header is that it enables the farmer to harvest his small grains and his feeding grains with the same machine. As it cuts a number of rows at a time, the work is done rapidly and a large area is easily handled.

Two facts still prevent the general use of the grain header for these crops, viz, their height and the presence of pendent heads in some varieties. Here is a problem in selection for the farmer. Dwarf strains of kafir must be perfected to equal the Dwarf milo already so popular. Varieties with erect heads must be had in all milos and durras.

PENDENT HEADS.

There are four great groups of grain-producing sorghums now under cultivation in this country. These are milo, durra, kafir, and kowliang. The first two groups originally had pendent or "goosenecked" heads (fig. 12). In the last two groups the heads are normally erect. The durras are but little grown because of the wasteful shattering of the seed, the irritating hairs on the glumes, and the pendent heads. A strain of White durra has been perfected in which 100 per cent of the heads are erect under all conditions. Improvement in the milos has not progressed so far. The percentage of erect heads varies from 50 to 95, depending, perhaps, more upon the character of the season than on the particular strain. This character does not yield readily to selection. It doubtless can be entirely eliminated, however, by long-continued selections.

Pendent heads seem to be the result of deep-seated habit in the plant. Because the largest, heaviest heads are most likely to be pendent, some persons believe that the bending is caused by the weight of the head. This is not true. The peduncle, or stem bearing the head, often begins to turn down as soon as the head comes out from the boot and before it is at all heavy with seed. Strong, vigorous stalks are most likely to produce pendent heads. Enough desirable stalks bearing erect heads can usually be found, however, to allow selections for erectness.

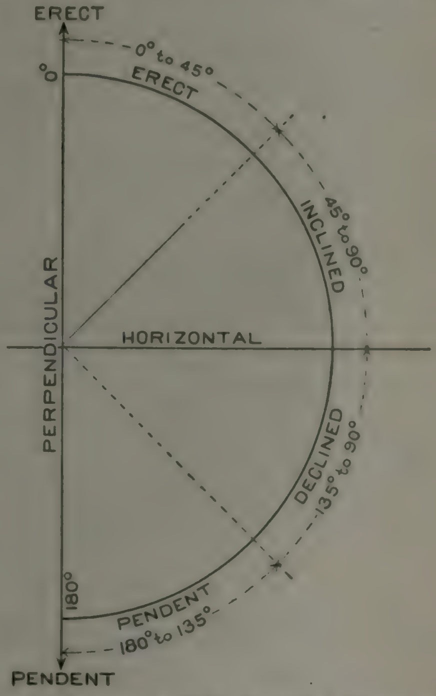

FIG. 13.—Diagram showing the named positions of heads of milo or durra.

Our experiments show that the planting of these crops rather thickly in drills tends to prevent too great a vigor of growth and therefore checks the production of pendent heads without decreasing the yield. With the same number of plants per acre, those planted in hills appear to produce more pendent heads than those spaced evenly in drills.

The diagram shown in figure 13 is tentatively suggested as an aid to those who are recording results in breeding these crops. The half circle through which the head may pass in shifting from the absolutely erect to the absolutely pendent position is divided in this diagram into four sectors of 45 degrees each. The head not inclined more than 45 degrees from the perpendicular is called erect, and is so for all practical purposes of harvesting. Between 45 degrees and the horizontal it is called inclined, and in the first 45 degrees below the horizontal it is called declined, while below that it is called pendent. Though all such heads are not really pendent, the header must be set about as low in order to harvest them as if they were hanging straight downward.

GIVE THE BOYS A CHANCE TO SELECT GRAIN-SORGHUM SEED.

Complaint is commonly made that the children are not interested in the farm and that many of them leave it as soon as possible. Interest can be awakened by giving the boys and girls something definite to do in the way of improving the farm and its products. Once started, they should be encouraged to feel responsible for results. They should also receive a money return, however small, for the improvement resulting from their efforts.

The formation of various boys' and girls' clubs, especially those for the growing of corn, is helping to create interest in the things of the farm. They are real steps in the right direction and should be extended to cover all farm crops, poultry, and live stock. But it is not necessary to await the formation of a neighborhood club in order to interest the boy in selecting better seed. Help him to make selections from the year's crop. Let him prepare it for storing over winter. Set aside a field on which he can plant it the following spring. Plant alongside it some unselected seed. Assist him in comparing the two fields. Encourage him if striking results are not obtained the first year. Give him a fair share of the profit when profit results from his labors. The best result will be the increase of interest and knowledge in the boy.

SUMMARY.

The "grain-sorghum belt," broadly speaking, is the southern half of the Great Plains region, nearly 400 miles wide and 1,000 miles long.

It is a region of low rainfall and high evaporation, of varied soils and considerable elevation, with correspondingly shortened seasons. It is suited to become a noted stock-feeding region.

The grain sorghums, including milos, durras, kafirs, and kowliangs, are of recent introduction and have become important only within the last 20 years. By their earliness, drought resistance, and adaptability they are especially fitted for growth under Plains conditions.

Sorghum grain is largely used for feeding stock on the farms where it is grown. Its feeding value is nearly equal to that of corn. The protein content averages higher than that of corn, the fat and fiber content lower.

Any surplus is readily marketed as whole grain or as chops for feeding purposes.

Sorghum grain is in much demand for poultry food, for which it is admirably suited. Over 25 per cent of the ingredients of prepared poultry foods in the eastern United States is kafir grain.

It seems probable that the meal can be used as readily as corn meal for human food and that both the meal and flour can be used in mixtures with wheat flour if desired.

Kansas and Oklahoma grow annually over 1,250,000 acres. It is probable that an equal area is grown in Texas also.

The grain-sorghum acreage in Kansas is nearly 10 per cent of the corn acreage and in Oklahoma over 12 per cent.

More than half the kafir and over 95 per cent of the milo is grown on the dry lands west of the ninety-eighth meridian. In this region the proportionate acreage of grain sorghums to corn is steadily increasing.

In spite of the less favorable conditions under which much of the crop is grown, the average acre value of the grain sorghums in Kansas is higher than that of corn, and in Oklahoma it is 70 per cent as great.

The grain sorghums may be greatly improved through the selection of better varieties and the use of better methods.

Improvement will be chiefly in the direction of (1) drought resistance, (2) earliness, (3) dwarf stature, (4) productiveness, including erect heads and freedom from suckers and branches, and (5) increased machine harvesting.

The drought resistance of the grain sorghums is very important. It is probably a combination of several characters, some actually drought resistant, as controlled transpiration and a strong root system, others only drought evasive, as earliness and dwarfness.

Improvement in earliness is necessary in adapting the crop to regions having a short growing season. Early plants take advantage of early seasonal rainfall and also have lower water requirements.

Milos, White durra, and some Brown kowliangs are normally early. Two early strains of Blackhull kafir have been produced, one tall and one dwarfed.

Dwarf stature lowers the water requirement of the crop and permits heading by machinery. Dwarf varieties are now to be had in all groups.

Better yielding varieties may be produced by selecting for well-shaped, well-filled heads, fully exserted from the boot and as large as possible in proportion to the size of the stalk.

The value of suckers in the grain-sorghum crops is doubtful. They are often shorter and usually later in maturing. Seed is so cheap and so little is used per acre that only a single stalk from each seed need be required.

Branches are utterly worthless for grain production in proportion to their objectionable features and should be eliminated.

Experiments show that under Panhandle conditions kowliangs give best yields with a stand of one stalk to each 5 or 6 inches of 3½-foot rows; milos and durras each 7 or 8 inches, and kafirs each 10 inches. Under different conditions the spacing will need to be varied somewhat.

Better results are probably secured from plants single in the drill than from the same number of plants in hills. Single stalks are also more easily selected and harvested and seem to produce fewer suckers.

To plant single seeds of the different grain sorghums two sets of plates are needed, with holes of different sizes, one set for milos and durras and one for kafirs and kowliangs.

To space different varieties properly in the drill, speed adjustments on the planter or plates with different numbers of holes will suffice.

The ordinary grain header harvests low varieties, like Dwarf milo, with complete success. The invention of satisfactory row headers or the growing of other dwarf varieties will solve the harvesting problem finally.

Pendent heads are usual in some varieties. They can be slowly eliminated by selection and proper planting.

The boys of the farm should be interested in seed selection to improve farm crops. Give them a chance with the grain sorghums.

[A list giving the titles of all Farmers' Bulletins available for distribution will be sent free upon application to a Member of Congress or the Secretary of Agriculture.]

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Issued May 12, 1911

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 449.

RABIES OR HYDROPHOBIA.

BY

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WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Animal Industry,
Washington, D. C., March 14, 1911.

Sir: I have the honor to transmit herewith, and to recommend for publication as a Farmers' Bulletin, a paper on "Rabies, or Hydrophobia," by Dr. John R. Mohler, chief of the Pathological Division of this bureau. This paper is based on an article which forms a part of the Twenty-sixth Annual Report of this bureau.

The disease known as rabies in animals and hydrophobia in man is one of the most terrible maladies known to medical science. Although some skepticism as to this disease persists and is industriously fostered by the publication of erroneous views, the reality and the infectious nature of the malady have been abundantly established and confirmed by the work of numerous competent scientific investigators, and there is no more reason for doubting the existence of rabies than for questioning the actuality of other specific and well-recognized contagious diseases.

Rabies is prevalent among dogs in various parts of the United States, and the presence of infected animals is a constant menace to human life. Under this condition the relative infrequency of deaths among people who have been bitten by rabid dogs is due to the protection afforded by the Pasteur treatment. Even with this treatment, however, considerable anxiety, suffering, hardship, and expense are entailed upon many people; and it must also be remembered that for a number of reasons, not the least of which are the inconvenience and expense involved, a large proportion of the persons and practically all the animals that have received the virus through bites do not undergo this treatment.

Theoretically, rabies is one of the most easily eradicated of contagious diseases, but practically the undertaking is beset with difficulties. All that is required is the muzzling of all dogs for a sufficient time. This has been amply proved by the experience of several European countries where the disease has been stamped out in this manner. But the carrying out of such a measure in this country is not easy. Effective action can not be taken by the Federal Government alone; it is necessary to have the cooperation of the States and municipalities and of the people at large. It seems desirable, therefore, that the information contained in the accompanying paper be given the widest publicity.

Respectfully, A. D. Melvin, *Chief of Bureau.*

Hon. James Wilson,
Secretary of Agriculture.

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RABIES OR HYDROPHOBIA.

NATURE AND CHARACTERISTICS OF THE DISEASE.

Skepticism with reference to the existence and prevalence of rabies in animals, or hydrophobia in man, strange as it may seem, is still entertained by a few prominent professional men. Their contention shows an unwillingness to accept the work of reputable investigators with regard to this particular disease, although other results obtained by the same investigators upon allied subjects are accepted and advocated. There is no greater galaxy of names associated with the study of any of the infectious diseases than is connected with the experimental investigation of rabies. The ablest scientists who have adorned the medical and veterinary professions, and to whom we owe the greatest deference for having advanced our knowledge of contagious diseases, have repeatedly shown by their experiments that rabies is a specific, communicable disease, preeminently affecting the canine race, although all warm-blooded animals, including man, are susceptible to it.

Many years of patient scientific research have been required to lead these investigators to a clear comprehension of the nature and characteristics of this disease. It was known and described several centuries prior to the beginning of the Christian era, and from the dawn of history the disease has been feared and dreaded. But it has been only in comparatively recent years that we have arrived at a tolerably clear understanding of the facts concerning this disease, which have to a certain degree displaced many of the fallacies and superstitions that have had a strong hold upon the public mind for many years. Indeed, it is still a widely prevalent belief that if persons or animals are bitten by a dog they are liable to become rabid if the dog should contract the disease at any future time. There is no foundation for this impression, and it would be a great comfort to many people who are now and then bitten by animals if the fallacy of this idea were appreciated. All experience, both scientific and practical, goes to show that rabies is transmitted only by animals that are actually diseased at the time the bite is inflicted. Under natural conditions this is the sole method by which the disease is transmitted, and therefore the old idea of spontaneous generation of the malady is absolutely fallacious. Artificially, it may be readily produced by inoculating susceptible animals with an emulsion of the brain or spinal cord or with the saliva, milk, and other secretions of the affected animal. The blood, on the other hand, seems to be free from the infectious principle. The saliva contains the virus which under natural conditions is introduced into or under the skin on the tooth of the rabid animal.

Following the canine race, cattle seem to be the most frequently affected, probably because rabid dogs, next to their morbid desire to attack members of their own race, have a better opportunity to bite grazing cattle than any other species of animals. The relative frequency of rabies in these two species of animals is indicated by the carefully compiled statistics of the German Empire, which show that 560 dogs and 78 cows died of rabies in 1901, while in 1902 there were 516 cases in dogs and 77 in cattle.

Every animal or person bitten does not necessarily develop the disease and the percentage of fatalities has been variously estimated. According to Hogyes the proportion of persons who contract the disease after being bitten by rabid dogs and not treated is conservatively estimated at 15 per cent. The percentage is considerably higher in man following bites by the wolf. From 35 to 45 per cent of the dogs, 40 per cent of the horses, 36 per cent of the hogs, and from 25 to 30 per cent of the cattle bitten by rabid animals contract the disease, making a general average of about 30 per cent. This, however, depends on the location and size of the wound, as well as the amount of hemorrhage produced, and various other conditions. In general, the nearer the bite is located to the central nervous system, and the deeper the wound is inflicted, the greater is the danger of a fatal result. In cases where the hemorrhage resulting from the bite is profuse, there is a possibility that the virus will be washed out of the wound and thus obviate the danger of subsequent appearance of the disease.

The virus after being deposited in the wound remains latent for an extremely variable period of time, which also depends on the size and depth of the wound as well as its location and the amount of virulent saliva introduced. Experiments have proved that the virus follows the course of the nerves to the spinal cord and along the latter to the brain before the symptoms appear. Gerlach, having collected statistics from a large number of cases, has found the period between the bite and the appearance of the first symptom to vary from 14 to 285 days. The great majority of cases, however, contract the disease in from three weeks to three months after the bite has been inflicted. It has been clearly demonstrated by the experiments of Roux and

Nocard that the bite of a dog is infectious at least three days before it manifests symptoms of rabies, while at the Athens (Greece) Pasteur Institute infection was noted in the saliva eight days before the dog showed signs of the disease.

CAUSE OF THE DISEASE.

Rabies is a specific infectious disease involving the nervous system and characterized by extreme excitability and other disorders, practically always terminating in death. The contagion of this disease has never been isolated, but the fact that the disease is caused by a specific organism principally found in the nervous system is indisputable. For instance, if an emulsion of the brain of a rabid animal is rapidly filtered through a fine Pasteur-Chamberland filter, the filtrate will be harmless. On the other hand, if a similar emulsion is filtered through the more porous Berkefeld filter, the virus will be found in the filtrate. This fact indicates that the infectious principle is not in solution, but is an organism of such size as to be withheld from the filtrate by a very fine filter. Further proof of the organic nature of the virus is furnished by the fact that heating at 50° C. for one hour will render the virulent emulsion inert, while similar results follow its exposure to light for 14 hours, to the usual antiseptic solutions for a short period, or to the action of the gastric juice.

This contagion can be propagated only in the body of an animal, and despite numerous attempts to cultivate it artificially upon various culture media only negative results have followed.

There is no doubt that between rabies and other well-known infectious diseases there are analogies at many points, the most striking being the protective immunization which constitutes the great work of Pasteur. Moreover, the disease is transmitted from one animal to another through a long series, which indicates the presence of a living organism capable of multiplication, rather than a mere toxin which would naturally become greatly diluted and innocuous by passage through such a series. In addition, the behavior of the disease makes us certain that it is caused by a specific micro-organism which, after introduction into the body, undergoes a period of incubation, during which it multiplies and subsequently produces certain definite symptons and lesions which terminate in death.

Innumerable attempts have been made to discover the causative agent, and investigators have announced the finding of many of the lower forms of animal and vegetable life as the pathogenic factor. Among the recently described causes certain protozoan-like bodies, found in 1903 by Negri in the ganglionic cells, and termed Negri bodies, are of a very suggestive nature. Negri claims that these bodies are not only specific for rabies but that they are protozoa and the cause of the disease. His work has been corroborated by investigators in all parts of the scientific world. An examination of the vitality of Negri bodies will show a striking resemblance to the vitality of an emulsion of the virulent tissue. Thus, Negri bodies have been found to be quite resistant to external agencies, such as putrefaction, drying, etc., and are about the last portion of the nerve cell to survive the advance of decomposition. They are also found in over 96 per cent of the cases of rabies examined, but have not been proved to exist in other diseases.

Valenti states, as his strongest evidence of the protozoan nature of the bodies, that the virus of rabies is neutralized in test tubes by quinin, while no other alkaloid has this property. As a result of the work performed in the New York City board of health laboratory, Park claims that Negri bodies are found in animals before the beginning of visible symptoms, and evidence is given that they may be found early enough to acount for the infectiousness of the central nervous system. These bodies are now almost universally considered as diagnostic of rabies, and in the pathological laboratory of the Bureau of Animal Industry their detection in the nerve cells of the brain suffices for a diagnosis of rabies without animal inoculations. In case these granular bodies are not found in a suspected animal, the plexiform ganglion is next examined, and should negative results still be obtained the inoculation of rabbits is then made as a last resort. It is indeed rare that positive results are obtained from the latter method after the first two methods have been negative, but it has occurred occasionally in cases where the animal had been killed in the early stages of the disease.

SYMPTOMS.

The symptoms of rabies are quite characteristic, and may be divided into two types—(1) the furious, violent, or irritable, and (2) the dumb or paralytic. They vary somewhat in each species, but as the disease in the dog is the most important, it will receive principal attention at this time.

FURIOUS RABIES IN THE DOG.

Following the period of incubation of the disease, which is usually between three weeks and three months, there is first noticed in the furious form of rabies a marked change in the disposition of the animal, which should at once arouse suspicion. An affectionate dog may become morose and depressed, while a snapping, treacherous animal may become cowardly or affectionate. This is known as the stage of development, and in one or two days is followed by an irresistible tendency to roam. If prevented the dog will fight or bite at the restraint or at anything that interferes with his freedom. This roving may occur for one to three days, during which he travels aimlessly in a nervous and irritable condition. His instinctive methods of defense are nearly always highly developed or exaggerated, but he seldom willfully attacks persons or other animals without provocation. When he returns, if not destroyed in the meanwhile, he shows from his exhausted, dirty, sheepish, or depressed appearance evidences of wandering. Having returned home, he frequently seeks secluded places such as are found under the house or porch.

During this period of roving he exhibits a disposition to eat or chew indigestible objects, as rags, leather, straw, feathers, sticks, and even pieces of coal, which are often swallowed. The secretion of saliva in some cases appears to be excessive, owing to the inability to swallow, and it sometimes becomes frothy from the champing of the jaws. However, foaming at the mouth is not a constant symptom of rabies, as is commonly believed by the layman; and furthermore, it is frequently misleading owing to the fact that it may be observed in other diseases. The erroneous opinion among the laity that dogs suffering with this disease are afraid of water is also misleading, since such dogs have been known to swim streams in their roamings. On the other hand, they appear to be afraid of nothing, as is evidenced by attacking all animals regardless of size.

A change in the voice of the animal is peculiar to this affection, and is due to the beginning paralysis of the throat, which usually sets in early. Instead of the normal bark the affected dog makes a long, resonant, peculiarly drawn-out bark which has been likened to the yelp of a coyote. Later, as the paralysis gradually extends, barking and swallowing become impossible, although attempts may be made to swallow. At this stage the muscles of the jaw become paralyzed, causing the lower jaw to drop and the tongue to hang out, which makes it collect dirt and appear dry and darker in color. Owing to this latter symptom the disease has been termed "black tongue" in certain sections. Upon closer observation the pupil of the eye is frequently found to be dilated. The paralysis continues to extend, the hind legs become involved, and the dumb form of the disease results. Finally death follows in from four to eight days after the development of the first symptoms.

DUMB RABIES IN THE DOG.

The dumb or paralytic form of rabies is much more infrequent than the furious type, and is characterized by the early appearance of paralysis without symptoms of frenzy or irritability which are observed in the early stages of the furious form. Therefore the animal affected with this type of the disease is not capable of doing much damage. Indeed the dog is much depressed from the beginning and seeks quiet spots or hides in some secluded place. Probably the first symptom noted by the owner is the paralysis of the lower jaw, as a result of which the animal is often suspected of having a "bone in its throat." The paralysis quickly progresses until it involves the legs and trunk and results in death in from one to three days.

RABIES IN CATTLE.

In cattle both furious and dumb rabies are met with as in dogs, the former being the more common. However, a sharp line of distinction can not always be drawn between these two forms of the disease, as the furious type usually merges into the dumb, due to the paralysis which always appears prior to death. The typical cases of dumb rabies are those where the paralysis occurs at the beginning of the attack and remains until the death of the animal. The disease first manifests itself by loss of appetite, stopping of the secretion of milk, great restlessness, anxiety, manifestation of fear, and change in the disposition of the animal. This preliminary stage is followed in a day or two by the stage of excitation or madness, which is indicated by increasing restlessness, loud bellowing with a peculiar change in the sound of the voice, violent butting with the horns and pawing the ground with the feet, with an insane tendency to attack other animals, although the desire to bite is not so marked in cattle as in the canine race. About the fourth day the animal usually becomes quieter and the walk is stiff, unsteady, and swaying, showing that the final paralysis is coming on. Loss of flesh is extremely rapid, and even during the short course of the disease the animal becomes exceedingly emaciated. The temperature is never elevated, but usually remains about normal or even subnormal. Finally there is complete paralysis of the hind quarters, the animal being unable to rise, and, but for irregular convulsive movements, lies in a comatose condition and dies usually in from four to six days after the appearance of the first symptoms.

RABIES IN CATS.

When the disease attacks cats, these animals generally hide themselves under the furniture or in some dark hidden corner, and there they may die unobserved in the course of a day or two. As a rule, however, the disease implies danger for human beings. The rabid cat becomes very bellicose; from the dark corner where it has hidden itself it will suddenly attack animals or persons, and especially when children are involved it will jump up to the face and inflict severe wounds with its teeth and claws. In the violence of this attack it frequently bites itself. The rabid cat loses its voice, being able only to mew hoarsely. Later it loses its appetite, has difficulty in swallowing, becomes emaciated, and succumbs within several days with symptoms of paralysis.

Horses, sheep, goats, hogs, chickens, and animals of prey such as wolves, foxes, badgers, and martens also contract rabies when bitten by rabid animals, and behave quite similarly to rabid dogs, cattle, and cats.

POST-MORTEM APPEARANCES.

In rabies there are no constant or definite lesions observed on post-mortem examination of the carcass. In fact, the alterations are slight, variable, and almost absent at times, so that unless there is a good history or characteristic symptoms a positive diagnosis can not be made without recourse to microscopic examination or animal inoculations of the brain of the suspected animal. The most suggestive indication of rabies is the presence in the stomach of unusual bodies such as stones, wood, earth, cloth, iron, feathers, etc. Frequently the stomach is empty of food, but distended with material of this character. Its mucous membrane is frequently injected, and at times a marked reddening of the folds of the stomach, with or without erosions, is noticed. There may also be an inflammation of the covering of the brain and cord as well as of the mucous lining of the mouth, throat, and respiratory tract. The feet of rabid dogs may present sores and bruises, denoting extensive travel which had been accomplished during the period of roving. The heart and pericardium are often inflamed, but these and similar lesions are more frequently due to the condition of the animal before dying than to any specific alteration. The carcass rapidly undergoes decomposition.

TRANSMISSION OF THE DISEASE BY MILK AND MEAT.

While the virus of rabies is most frequently found in the central nervous system and the salivary glands, it may also be found in other glands and secretions, including the mammary glands and the milk. That rabies may at times be excreted with the milk has been proved by Nocard, Perroncito, Bardach, and the writer. In these latter experiments the milk of a rabid bitch having a litter of puppies was inoculated intramuscularly into rabbits and guinea pigs, and produced typical rabies; but the puppies, removed from the mother when the first symptoms developed, were kept under observation for 18 months without developing the disease. The reason for these negative results in the puppies may be explained (1) by not having been bitten by the mother before she was removed, and (2) the absence of any abrasion in the alimentary tract through which the virus could have entered the circulation.

It is a generally accepted fact that rabies can not be transmitted to normal animals through food containing the virus of the disease unless lesions are present in the alimentary canal; but the conclusion that there is no danger to the consumer from the meat or milk of animals that are rabid is not tenable, since abrasions of the lips, mouth, and pharynx are all too frequent to permit of such risks. These products must therefore be considered as dangerous to health.

One case is on record where a baby in Cuba developed rabies from nursing its mother while the latter was in the early stages of hydrophobia. In this case, however, the virus in the milk may have entered the circulation through abrasions of the gums during teething. Similar cases have been reported in veterinary practice where the virus of rabies was observed to have been passed to the offspring through the mother's milk, but in these cases it is impossible to eliminate an obscure bite from the bitch or lesions of the gums during this early age. While it is not probable that cattle would be milked after the symptoms of rabies developed, it is nevertheless important to realize the danger of using such milk and the necessity for preventing calves from sucking such diseased cows.

All attempts to convey the disease to healthy dogs by feeding them upon meat from infected animals have given negative results.[1] Nevertheless the meat of rabid animals must be considered as unfit for food, and the meat-inspection regulations enforced by the various countries having such inspection provide for the total condemnation of the carcasses of these animals.

Infection has occurred in man from making autopsies on rabid dogs, and it is likewise possible to result if inoculation occurs while handling the meat of rabid cattle, hogs, or sheep. Ostertag reports the case of a veterinary student at Copenhagen who infected a wound on his finger while making an autopsy on a dog dead of rabies and died of the disease. Another somewhat similar case occurred in a veterinary student at Dresden in consequence of an injury received while holding a post-mortem on a rabid dog.

Wyrsykowski, in an attempt to discover the reason for the fact that no illness followed the eating of the meat and even the brain of rabid animals, tested the action of the gastric juice upon infectious material in vitro. Twenty-one rabbits were inoculated with this artificially digested virus, but not one animal contracted the disease, while all the

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[1] Claudio Fermi has recently produced rabies in rats and mice by feeding them rabietic material with their food. About 60 per cent of the 70 animals so fed died of paralytic rabies.

17 check rabbits which were inoculated with undigested rabies virus developed the disease and died. It is evident, therefore, that the gastric juice has a pronounced deleterious effect upon the virus of rabies.

DIFFERENTIAL DIAGNOSIS.

The present advocates of the assumption that rabies is a disease of the imagination should be better fortified in both their facts and their theory. Little children certainly do not die after a dog bite from the effects on the imagination, nor do horses, cattle, sheep, hogs, dogs, rabbits, and monkeys die from an imaginary disease. It must be more than a mere coincidence that ever since the recognition of this disease in the days of Aristotle this peculiar mode of death has occurred only after infection by a rabid animal. The daily newspapers may add to the sensational details of these occurrences, but there is no doubt of the real danger involved.

Anyone who has seen the suffering of one human being affected with this fatal disease will readily concede that no amount of inconvenience caused animals by muzzling or other protective arrangement can ever be considered too much to prevent such suffering, nor should it prove difficult to differentiate between hydrophobia and the pseudo form, which has been termed lyssophobia, if all the cases of these diseases were as typical as the two which were brought to the writer's attention.

Through the courtesy of Dr. William C. Woodward, health officer of the District of Columbia, I was invited to visit Freedmen's Hospital for the purpose of seeing a patient whose case had been diagnosed by the resident surgeon as suspected hydrophobia. The woman, 28 years of age, had been fiercely attacked and severely bitten on the right forearm and about the face by a stray collie dog. Eighteen days later she complained of a general malaise and pains in the cicatrized wounds of the head, which rapidly grew more severe, necessitating the services of a physician, upon whose advice the patient was removed to the hospital on the following day. My visit occurred on the afternoon of the succeeding day, at which time the patient was found in an extremely nervous condition, having an excessive feeling of fear and uneasiness. The eyes were staring and a general expression of anxiety pervaded her countenance. Her mind was clear, and no efforts at violence were made. When interviewed as to the scars on her head and forearm she lightly replied, "Oh, a dog bit me there some weeks ago, but they are all right now."

From time to time reflex spasms involving the muscles of deglutition were noticed, causing a clutching at the throat and difficult breathing during the attack. These rapidly became more generalized and soon involved the respiratory muscles, causing dyspnea.

Attempts at vomiting would then occur, but no evacuations followed. Contrary to the views of our skeptical friends, the patient accredited these symptoms to indigestion, and had not the slightest suspicion of the true nature of her condition, thus disproving the idea that the nervousness and fear usually seen in the early stages of rabies in the human subject are due to the natural dread of the disease and apprehension of the consequences rather than to organic changes in the central nervous system. During the night these symptoms became more aggravated and spasms followed one another more rapidly, causing grave delirium. The patient finally became violent, requiring the adoption of forcible measures to keep her under control. Death occurred on the following morning, 21 days after the bites had been inflicted. On post-mortem examination no pathological lesions were found which could be held accountable for the symptoms which resulted in death, but histological examinations of the plexiform ganglia and the medulla, as well as the inoculation of rabbits, both subdurally and intramuscularly, with an emulsion of the brain, resulted in the confirmation of the diagnosis of hydrophobia.

That the appearance of a disease like rabies in a community seems peculiarly and in an extraordinary degree to be associated with an atmosphere of hysterical simulation and to inspire states of auto-suggestion must be admitted. One case of this character recently came to my attention through the kindness of a local physician which is in direct contrast to the instance cited above.

A young man, 24 years of age, employed as a clerk in a dry goods store, was bitten on a Saturday morning by a watchdog belonging to the proprietor. The bite, which was slight, had been immediately cauterized, and no further attention was given to the incident until Wednesday morning, when the young man fainted at the counter. Upon reviving he stated that he had been reading about rabies and the symptoms which would develop in man from the bite of a rabid dog, and insisted that he was developing hydrophobia as a result of having been bitten by the watchdog. He was immediately sent to his home and the dog brought to the bureau to be kept under observation. Two days later the young man was in a very hysterical state and kept insisting that the dog that bit him was rabid. During this time the patient had been in bed, and seemed to have had marked paroxysms. He would roll himself over and over in bed, snarling, growling, and snapping at the bed clothes. He would catch the pillow or sheet with his teeth and shake it like a terrier shaking a rat, and in numerous other ways would show more imitative accuracy than in the genuine disease. At first it was impossible to attract his attention, although he would mutter and talk to himself. When he was informed that the dog that bit him did not have rabies, that it was alive and well, and that even if it did develop rabies several weeks later it would have no bearing on his case, as the saliva would not be virulent such a long period before the development of the symptoms in the dog, and furthermore that he had developed symptoms entirely too soon after the bite had been inflicted, as a longer period of incubation had to intervene for the virus to multiply and produce its effects, he commenced to realize that he had been making himself a victim of autosuggestion, and rapid recovery followed.

Here was a typical case of lyssophobia or pseudo-rabies, a figment of an overworked imagination, and, as in all cases of this class, recovery took place instead of death, which is always the termination of the true disease.

It has been stated by certain physicians that tetanus (lockjaw) is undoubtedly the true cause of death in the majority of instances where rabies has been diagnosed. It is not my purpose to give a differential diagnosis between these two diseases in man, but there is such a marked difference between a horse affected with tetanus and one with rabies, or a cow affected with tetanus and one with rabies, or a dog affected with tetanus and one with rabies, that a few brief words on differential characteristics will be given.

Tetanus may be readily differentiated from rabies by the persistence of muscular cramps, especially of the neck and abdomen, which cause these muscles to become set and hard as wood. In tetanus there is also an absence of a depraved appetite or of a willful propensity to hurt other animals or damage the surroundings. The general muscular contraction gives the animal a rigid appearance, and there is an absence of paralysis which marks the advanced stage of rabies. The dumb form of rabies in dogs is characterized by a paralysis and pendency of the lower jaw, while in tetanus the jaws are locked. This locking of the jaws in horses is very characteristic, and in cattle or dogs it renders the animals incapable of bellowing or barking as in rabies. Finally, tetanus may be distinguished from rabies by the fact that the central nervous system does not contain the infectious principle, while in rabies the inoculation of test animals with the brain or cord of a rabid animal will produce the disease with characteristic symptoms after an interval of 15 to 20 days. This period of incubation is much longer than in tetanus, since the inoculation of rabbits with tetanus bacilli invariably results in death after a short period, usually within 3 or 4 days.

DISTRIBUTION AND PREVALENCE.

There is no intention of assuming the part of an alarmist with reference to the increasing prevalence of rabies. It can not be denied, however, that there is at present unusual occasion for alarm in certain parts of this country. It may be true that many newspaper stories have been exaggerated or are entirely false, but it is not true that all are fabrications. This is shown by a number of cases traced by the writer where the diagnosis had been made in reputable laboratories by recognized scientists. Kerr and Stimson in their investigation of the prevalence of rabies used a number of press clippings, and in no instance did a press report lack official confirmation, which is quite contrary to the general opinion on this subject.

IN THE UNITED STATES.

In looking over the proceedings of the American Veterinary Medical Association for the past 12 years, it was observed that rabies is reported as existing in a number of States each year, although there has been no special endeavor on the part of the resident State secretaries to ascertain the extent of this particular disease in their sections. In 1897 the disease was reported in 4 States, in 1898 in 5 States, while in 1899 the statement of Huidekoper was cited by Parker to the effect that the disease was not west of the Rockies and was rare in the United States except in Pennsylvania and Massachusetts. However, in the 1900 report we find that the disease had appeared in Montana, Wyoming, and Colorado, in addition to certain Eastern and Central Western States. It is evident from the succeeding reports that the disease was becoming more widespread, and at the meeting of the American Veterinary Medical Association in Philadelphia in 1908, of the 20 resident State secretaries who reported, 13 incidentally mentioned the existence of rabies in their States, and in Alabama, Connecticut, the District of Columbia, Minnesota, Mississippi, and Ohio the disease seemed to be on the increase. As there was no apparent reason for mentioning the presence or absence of this disease, the failure of the reports from the remaining 7 States to refer to rabies should not be considered as indicative of its absence. In fact, the writer has corresponded with officials in these 7 States, and replies have been received from 5 of them to the effect that rabies had prevailed in their localities during 1908, thus showing that the disease existed in 18 of the 20 States mentioned in the 1908 report. We have gone even further in our correspondence and have endeavored to find out if there is any State or Territory in the United States where rabies is unknown. From the information at the writer's disposal it would appear that the disease occurs in almost every State in the Union, and the only places where it has been impossible to obtain positive information are Idaho, Utah, Nevada, and Oregon,[1] while in the State of Washington there has been but one outbreak, which was quickly suppressed 7 years ago. It would be entirely impracticable without registration laws to ascertain the extent of the disease among animals in the various infected sections, but the disease appears at times in certain centers with all the vigor of an enzootic, and such outbreaks have occurred recently in Jacksonville, Fla.; El Paso, Tex.; Norfolk, Va.; Kansas City, Mo.; Boston, Mass.; Chicago, Ill.; Baltimore, Md.; Washington, D. C.; Cleveland, Ohio; Pasadena and Los Angeles, Cal.; and certain sections of New York, Pennsylvania, Minnesota, Ohio, Missouri, and Michigan. Not only is there a gradual increase in the number of outbreaks of rabies, but many new centers which appear to be more or less permanent are being established from year to year. The fiscal year 1909 is the first year when over 100 cases of rabies have been diagnosed in the Pathological Division of the Bureau of Animal Industry, and of the positive cases, 79 came from the District of Columbia and 33 were divided among Virginia, Maryland, West Virginia, and South Carolina.

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[1] Rabies has been reported in Oregon by Pernot since this paper was written.

The following table, prepared by Kerr and Stimson, of the United States Public Health and Marine-Hospital Service, gives a partial list of the number of laboratory diagnoses of rabies found in 1908 at the various institutions interested in the investigation of this disease. They call attention to the fact that these figures represent in many instances only a small proportion of the actual number of cases of rabies occurring in the various States. For example, while only 47 cases of rabies have been actually demonstrated in Wisconsin, the State veterinarian estimates that 584 animals died of this disease during 1908.

Positive findings of rabies in animals, 1908.

Diagnosis made by—	Number.
Delaware State Board of Health laboratory	7
Connecticut State Board of Health laboratory	14
Florida State Board of Health laboratory	20
Indiana University, Bloomington, Ind	12
Indiana State Board of Health laboratory	75
Baltimore (Md.) Pasteur Institute	74
Massachusetts cattle bureau	135
University of Michigan Pasteur Institute	101
New Hampshire State Board of Health	7
New Jersey State Board of Health	13
New York Pasteur Institute	60
North Carolina State laboratory of hygiene	21
Vermont State Board of Health	2
Wisconsin State hygienic laboratory	47
New York State Veterinary College	188
Minnesota State live-stock board	15
Bureau of Animal Industry, Pathological Division, Washington, D. C	121
Cleveland health department, east side	49
Pennsylvania State live-stock sanitary board	103
Ohio State Board of Health laboratories	32
Virginia Pasteur Institute, Richmond	39
Biological laboratories, Brown University, Providence, R. I	32
Total	1,167

In a letter from former State Veterinarian Langley he states that Texas probably has more rabies than any other State in the Union. Several years ago President Frank Wells, of the Michigan State Board of Health, made rabies largely the subject of his annual address and declared it was epidemic in Michigan. Vaughan, who reported as a special committee on rabies, intimated that it had gradually spread from New York, where it had prevailed for a number of years previously, into Ohio and thence to Michigan, having been diffused throughout the Lower Peninsula of Michigan. In fact, the disease became so widespread and so many people were bitten that the State appropriated funds for the establishment of a Pasteur institute in connection with the medical department of the University of Michigan. A Pasteur institute was likewise established in April, 1908, in Washington, D. C., in connection with the Hygienic Laboratory of the United States Public Health and Marine-Hospital Service, owing to the continued outbreak of rabies in that vicinity and the large number of people bitten by rabid animals, 139 persons having been treated since its establishment. In addition, there are 18 other Pasteur institutes in the United States, located at Atlanta, Ga.; Austin, Tex.; Baltimore, Md.; Chicago, Ill.; Iowa City, Iowa; Jacksonville, Fla.; Minneapolis, Minn.; Montgomery, Ala.; Newark, Del.; New Orleans, La.; Pittsburg, Pa.; Raleigh, N. C.; Richmond, Va.; St. Louis, Mo.; two in Indianapolis, Ind.; and two in New York City.

As an indication of both the distribution and the prevalence of rabies among animals may be considered the number of persons who have been treated at these institutes. The directors of these Pasteur institutes have been requested to furnish this information, and the majority have responded. From these reports it is evident that several thousand people have been subjected to the Pasteur treatment recently, and hundreds (nearly 1,500 persons in 1908) receive the treatment every year as a result of bites inflicted by rabid animals. At the Pittsburg institute 1,022 persons from Canada, Ohio, Pennsylvania, New York, West Virginia, and Colorado have received treatment, as follows:

From December, 1900, to September, 1902, 76 cases.
From October, 1902, to October, 1904, 143 cases.
From October, 1904, to October, 1906, 185 cases.
From October, 1906, to October, 1908, 368 cases.
From October, 1908, to June, 1909, 250 cases.

The Texas institute, under State control, has been established less than 5 years, but the number of persons who have applied for treatment has gradually increased from 81 in 1905 to 254 in 1906, 310 in 1907, and 353 in 1908, these patients coming from 7 Southwestern States and old Mexico.

At the St. Louis institute 381 persons have been treated, coming from 11 Southern and Central Western States and from Mexico.

Since 1890 the Chicago institute has treated 3,016 people, coming from 30 different States of the Union.

At the New York institute (Rambaud's) 1,367 cases were treated between 1890 and 1900, 237 cases in 1900 and 1901, and 486 cases from October, 1904, to October, 1906.

Brawner, of the Georgia institute, has treated 670 patients since 1900, with only 2 deaths. During this time all the people in Georgia bitten by rabid animals so far as could be learned, and who did not take the treatment, were recorded, and of the 120 bitten without subsequent treatment 29 have died. Rabies is said to be very much on the increase in that section, and it is not uncommon for farmers to lose many horses, cows, and hogs from the disease.

At the Baltimore institute 1,092 cases have been treated, 334 of which came from Maryland, 117 from North Carolina, 102 from Pennsylvania, 104 from Virginia, 112 from West Virginia, 57 from the District of Columbia, and the remainder from 13 other States.

Since 1901 the Richmond institute has treated 208 cases, coming from Virginia, North and South Carolina, and West Virginia.

As a further indication of the number of persons bitten but who did not take the Pasteur treatment are the census reports showing the mortality statistics from rabies. In the census of 1900, when only about 40 per cent of the population resided in districts where registration was observed, 123 deaths from rabies distributed in 20 States were reported. That this number was entirely too low was shown by Salmon in 1900, who corresponded with a number of health officers within and without the registration districts and collected 230 authentic cases of hydrophobia in man during this same interval in 73 cities.

That the increase of rabies in animals which has been demonstrated above bears a direct relation to the increase in the disease in man is shown by the vital statistics of the Census Bureau, as follows:

In 1903, 43 people died of rabies; in 1904, 38; in 1905, 44; in 1906, 85; in 1907, 75; in 1908, 82. These deaths occurred only in the registration area of the United States, which now includes about 51 per cent of the total population.

IN OTHER COUNTRIES.

While the disease in certain foreign countries has at times appeared in the form if severe enzootics extending over considerable territory, in the course of the last decade the affection has decreased on the whole, and in some places has even disappeared entirely, owing to the rigid enforcement of muzzling and quarantine regulations. According to Hutyra and Marek the disease in France is widely distributed all over the country. Since 1899 more than 2,000 cases of rabies in animals have been reported each year, and in 1903 there were 2,391 rabid animals. In Germany during the years 1895 to 1898 the number of cases of rabies increased rapidly from 489 to 1,202. The number then decreased to 612 in 1902. These cases occurred mainly in the eastern and southern provinces bordering on the badly infected districts in Russia and Austria, while in the other parts of Germany only a few isolated outbreaks of the disease appeared. In Austria the disease has been on the increase since 1891, and in 1900 there were 1,187 cases reported. During this interval—from 1891 to 1900—4,974 people were bitten by rabid animals, 123 or 2.4 per cent of whom died of hydrophobia. In 1903 the number of people bitten by mad dogs varied from 11 to 42 weekly. In Hungary there was a momentous decrease in rabies following the passage of the veterinary sanitary law of 1888, but since 1893, when there were 883 cases, outbreaks have been gradually increasing, and in 1903, 2,040 rabid animals were reported. The disease is most common in Russia, and it also appears very frequently in Roumania, Servia, and Bulgaria. In Turkey, despite the large number of dogs, the disease does not increase much, which is explained by Remlinger by the fact that the affection generally appears in the form of dumb rabies. In 1903 only 35 rabid animals were reported in Belgium, 25 in Holland, 18 in Switzerland, and 376 in Italy. Spain has had more frequent outbreaks of the disease, while Denmark, Sweden, and especially Norway and Great Britain, have been free from the contagion for several years owing to the wise provision that all dogs running at large shall be muzzled. The islands of Australia, Tasmania, New Zealand, St. Helena, and the Azores have never become infected with rabies, and the first three prevent its introduction by rigid inspection and quarantine. In 1905 Rutherford reported the disease to be spreading in Canada, and in 1908 Dudley made a similar statement for the Philippine Islands, where the malady had been found to exist in 39 provinces. The latter recommends the establishment of a Pasteur institute in the islands. That rabies is increasing in Mexico is shown by the report of the Pasteur institute in the City of Mexico. For the 20 years since this institute was established 8,680 patients from all the Federal States of Mexico have taken treatment, 4,579 of these people receiving the treatment during the last six years. The disease is also known to occur at infrequent intervals in certain sections of South America, Africa, and Asia.

PREVENTION AND ERADICATION.

Sanitary regulations which seek to control the disease effectively by exterminating it among dogs are most likely to prove successful. There is no communicable disease which is more easily prevented or eradicated than rabies. Since the infection is practically always transmitted by a bite, and since the animal which does the biting is almost always a dog, all sanitary measures must be directed to the control of these animals for a sufficient time to cover the incubation period of the disease. It seems inexcusable, therefore, to allow this contagion to be propagated indefinitely, causing untold suffering to the affected animals and menacing the lives of persons, particularly children, who go upon the streets.

The only measures necessary to obtain the desired result are (1) a tax or license for all dogs, with a fee of $2 for males and $5 for females, and the destruction of homeless or vagrant dogs; (2) restraint of all dogs which appear in public places, either by the use of a leash or an efficient muzzle.

DOG LICENSE.

There is no doubt that neglect has allowed the accumulation of ownerless dogs in this country to an extent that renders our large cities frequently liable to incursions of rabid animals. To even mention muzzling, however, is sufficient to bring tirades of abuse upon the head of the sanitarian, and dog sentimentalists are immediately up in arms, using time, influence, and money to prevent such an ordinance. In spite of the obloquy with which it is received by a certain mistaken class of the community, the results of muzzling amply justify its recommendation, and its rigid enforcement without any additional requirement will exterminate rabies in a district in a shorter time than any other known method. Even Dulles, the great controversialist on rabies, admits that he considers muzzling to be the most important measure for limiting the ravages of this disorder, no matter on what theory it may be accounted for. Excellent examples of its efficiency are shown by the well-known results obtained in eradicating the disease from England, Sweden, Denmark, Berlin, and in other communities.

NECESSITY FOR MUZZLING.

The striking results obtained by England have caused many persons to propose and advocate a national dog muzzling law for the United States, enforced by the Department of Agriculture. These suggestions, however, do not take into consideration the discrimination between the functions of the Federal and State Governments and the differences between the laws of the United States and those of England. The power conferred is not in all cases sufficient to effect the eradication of a disease, for the reason that the Federal Government can not enforce measures within a State without the legislative consent of the State unless the animals affected are subjects of or endanger interstate commerce. Its work, therefore, without the cooperation of the States affected, is limited to interstate traffic, and quarantine lines are thus made to follow State lines. The department is always willing to cooperate, so far as possible, with any State which requests assistance in eradicating an infectious disease. But such a State must necessarily have the proper laws by which the control of the disease is made possible. When a disease such as rabies is confined within a State it does not come under the jurisdiction of the Federal Government and can not be treated as the infectious diseases pleuro-pneumonia and foot-and-mouth disease, which spread from State to State and become a serious menace to interstate traffic. The Department of Agriculture could quarantine against States where the rabies exists, but it can readily be seen that owing to the great freedom of movement which dogs enjoy it would be impracticable to enforce such a quarantine further than to require all dogs to be muzzled which are being transported interstate by common carriers. Such a requirement would give an infinitesimal amount of protection, as these dogs would be beyond the Federal jurisdiction after reaching the State for which they were destined.

If all States should enact muzzling laws, or if the State boards of health, State sanitary boards, and municipal authorities in the infected States should be empowered to issue and enforce regulations compelling the muzzling of all dogs in the infected area and the impounding or humane destruction of all dogs found running at large, the disease would soon be stamped out.

The necessity for a muzzling order having arisen in the District of Columbia, the Secretary of Agriculture notified the District Commissioners of the presence of this disease in an alarming degree among the canines of Washington, and requested the enactment of a muzzling order. Such an order was deemed advisable because the disease had suddenly jumped from 12 cases during the fiscal year of 1906–7 to 61 cases in 1907–8. The Commissioners, however, believing that the most effective manner of dealing with the matter was to impound and destroy stray dogs, started to increase the dog-catching service on February 1, 1908, and from this time to June 15, 1908, there were 2,762 dogs impounded as compared with 1,185 dogs impounded during the corresponding period for 1907. The President of the United States became interested in the subject, and the Commissioners issued a muzzling order to be effective for a period of six months. With the extra wagons and force employed, the number of dogs captured during the period of the muzzling order was 4,355, as compared with 2,794 captured during the corresponding period of the preceding year. The cost of the service for the period of the muzzling order was $6,125, as compared with $2,243 for the corresponding period in the previous year. To further the execution of this order, 146 arrests were made and 134 convictions secured, besides what was accomplished by giving notice of a penalty for violation. In 1908, during the last six months of which the muzzling order was enforced, 8,225 dogs were impounded, while after the expiration of the muzzling order only 2,243 dogs were impounded during the first half of 1909. During the last six months of 1908, the period when muzzling was required, there were 46 cases of rabies, while in the first six months of 1909 there were only 28 cases. The results from the muzzling order were therefore becoming apparent, and an additional six months' quarantine was requested by the Secretary of Agriculture, but this request was not complied with by the District Commissioners.

In the last half of 1909 there were only 24 cases, but in the first half of 1910 the number rose to 34. During this time new Commissioners came into office, and as the disease persisted and showed a tendency to increase, they issued another muzzling order, taking effect August 11, 1910. Since that time the number of cases has gradually decreased, notwithstanding the fact that owing to the insufficiency of the appropriation the authorities have been unable to enforce the order adequately.

In order to secure State and municipal legislation for the control of rabies it will require concerted action on the part of all interested parties, whether professional men or laymen, to prove to the public the need, value, and benefits of such a procedure. With such legislation properly enforced no dog would be seen running at large without a muzzle. Those contracting the disease would be unable to transfer the virus to other animals. Monetary loss, untold suffering, and death among both human beings and animals caused by the disease would rapidly decrease, and in a relatively short period rabies would be eradicated from our country. After reaching this desired goal the reappearance of the disease could be readily prevented by a six months' quarantine of all dogs imported into the United States from countries where rabies is prevalent.

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Issued April 26, 1911.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 450.

SOME FACTS ABOUT MALARIA.

BY

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WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., March 24, 1911.

Sir: I have the honor to transmit herewith a manuscript, entitled "Some Facts About Malaria," which has been drafted to meet a strong demand for such information from persons connected with agricultural pursuits in various parts of the country, and more especially in the South. I recommend its publication as a Farmers' Bulletin.

Respectfully,
L. O. Howard,
Entomologist and Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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SOME FACTS ABOUT MALARIA.

INTRODUCTION.

It is a noticeable fact that in most parts of the world where antimosquito measures have been undertaken on a large scale the work has been done with the direct end of doing away with mosquito-borne diseases. In the United States, however, such antimosquito work as has been undertaken has almost invariably been done with the direct incentive of simply ridding communities or localities from a great nuisance. Almost the only exception has been the work done on Staten Island by Dr. Doty, the health officer of New York.

There are, however, many localities in the United States where malaria is prevalent, and some in which the existence of the disease in an aggravated form is a serious barrier to agricultural or industrial development. It has been shown, for example, that, agriculturally speaking, the lands of the Delta region of Mississippi and adjoining States are the richest in the whole world, with the possible exception of the delta of the Nile, and yet, on account of the extraordinary prevalence of malaria in this region, it is sparsely settled and land prices are low. The advance of the cotton-boll weevil into this section has had its customary effect of driving a considerable proportion of the negro labor into other regions not yet invaded, and unless the country is to become impoverished it will be necessary to import white labor. Negroes are more or less resistant to malaria, but this will not be true of the white labor coming into this region, which will undoubtedly become rapidly infected with the disease.

Malaria is not a difficult disease to fight. This has been shown in many parts of the world—in Italy, in Cuba, in Panama, in West Africa, in India, in Egypt, and elsewhere. People, generally, should know the exact truth about the disease and what is to be done. The efforts of individuals, after they have acquired the proper knowledge, will have an effect upon the malaria rate, while with a general knowledge of these facts community work must come sooner or later.

In the pages which follow, the statements regarding the disease itself are partly drawn, with the permission of the American publishers, from an admirable summary prepared by Dr. Ronald Ross,[1] of the Liverpool School of Tropical Medicine, who was the first discoverer of the relation between malaria and mosquitoes, something over 12 years ago, in India. His results were soon confirmed by workers in many parts of the world, and the statements here made are accepted by the best physicians of all countries.

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[1] See Ronald Ross, The Prevention of Malaria. London and New York.

THE DISEASE AND ITS CAUSE.

The disease known as malaria, or fever and ague, or chills and fever, or marsh fever, and the varieties called intermittent fever, remittent fever, and pernicious fever, are caused by parasites in the blood which feed upon the red blood cells.

Malaria occurs more or less in all warm climates, especially in the summer after rains and near marshy ground. It is said to cause one-fourth or more of all the sickness in the Tropics.

The parasites in the blood are microscopic one-celled animals called plasmodia.

These minute parasites are introduced into the blood through the proboscis of certain mosquitoes of the genus Anopheles.

On being introduced in this way, each parasite enters one of the red blood cells, in which it lives and grows.

When full grown, each parasite divides and thus produces a number of spores, which escape from the blood cell and enter fresh cells. This method of propagation may continue for years.

Although only a few of the parasites may have been introduced originally through the beak of the mosquito, they rapidly increase until millions upon millions of them may exist in the blood.

At first, when the number of parasites is still small, an infected person may remain apparently well. When, however, the number is large enough, he begins to suffer from fever.

The parasites tend to produce their spores all at the same time, and it is at the moment when these spores escape from the blood cells, almost simultaneously, that the fever begins.

The fever is probably caused by a little poison which escapes from each parasite with the spores.

After from 6 to 40 hours or more this poison is eliminated from the patient's system and his fever tends to leave him.

In the meantime, however, a new generation of parasites from the spores is approaching maturity; and when this is reached they in their turn break up and cause another attack of the fever like the first, and so on indefinitely for months and months. In this way the attacks of the fever follow each other at regular intervals.

But it often happens, as the result of repeated infections, that a new attack has commenced before the former one has ceased, so that they overlap and the fever continues.

After a time, even without treatment, the number of parasites may decrease until not enough of them are left to produce fever, in which case the patient improves temporarily.

It generally happens, however, sooner or later, that the number of parasites increases again, and the patient again suffers from a series of attacks.

Such relapses are frequently encouraged by fatigue, heat, chill, wetting, dissipation, or illness, and they may occur at intervals for a long time after the patient was first infected by the mosquito, and even after he has moved to localities where there is no malaria.

Besides fever, these malarial parasites often produce anemia and enlargement of the spleen, especially with patients who have suffered many relapses.

Death is often caused in malarial patients by other diseases, such as pneumonia or dysentery, the system being already weakened by the malarial parasites.

If the patient survives, the parasites tend to die out of themselves, without treatment, after a long period of illness, leaving him more or less immune.

The parasites are of at least three kinds, which can be easily distinguished in the blood if placed under the microscope. These are (1) a parasite which produces its spores every three days and causes what is called quartan fever; (2) a parasite which produces its spores every other day and causes tertian fever; (3) parasites which cause the so-called malignant fever or pernicious malaria, which is of an irregular type and in which dangerous complications most frequently occur.

Quinine kills the parasites when administered at the proper time; but generally it will not destroy all the parasites in the body unless it is given in sufficient doses and continued for several months. As long as a single parasite remains alive in the blood, the patient may be subject to relapses. Ross advises that at least 5 grains of sulphate of quinine should be taken by an adult patient every day without fail for four months, but he should consult a physician regarding the details of the treatment.

METHOD OF INFECTION.

The malaria parasite has several different stages. Aside from those forms which produce spores in the body, there are other stages—male and female. When one of these anopheline mosquitoes, which carries malaria, happens to feed on a patient whose blood contains parasites, these are sucked, with the blood, into the mosquito's stomach.

If the sexual forms of the parasites are present, those of opposite sexes at once unite. The parasite now undergoes certain changes in the mosquito's stomach. It passes through the stomach wall and finally affixes itself to its outer surface.

Here it grows very considerably and, after a week under favorable conditions, produces a large number of spores.

These spores, thus entering the general body cavity of the mosquito, find their way into the salivary glands. These glands secrete the irritating fluid injected under the human skin when the mosquito begins to feed.

Thus, when one of these mosquitoes, which has fed upon a malarial patient containing the sexual forms of the parasites, bites, after a week, another person, it injects these spores together with its saliva under his skin and generally into his blood.

These spores now cause or may cause infection or reinfection in this second person.

Thus the parasites of malaria pass from men to certain mosquitoes and back from these mosquitoes to men.

Malarial fever is then an infectious disease, which is carried from the sick to the healthy by anopheline mosquitoes, and only in this way can it be contracted.

It has always been known that malaria is most prevalent in the vicinity of marshes, and it was formerly supposed that the air or exhalations from these marshes produced the disease. Parasites of malaria have not been found in the water or air of marshes, nor in decaying vegetation, nor in the soil, although they have been diligently searched for. Attempts to produce infection by these agencies have always failed. The mosquitoes which carry these parasites, however, breed in marshes or in marshy pools and streams.

Issuing from these breeding places, they enter nearby houses and feed upon the inmates, mostly at night, biting first one person and then others, and living for weeks or months.

If an infected person happens to be present in any of these houses, the anopheline mosquitoes biting him will also become infected, and the disease is likely, ultimately, to be carried by these mosquitoes to others and to neighboring houses.

Thus a whole neighborhood soon becomes infected and the locality is called malarious. In such localities it is easy to find the parasites of malaria in the proper mosquitoes. Sometimes 25 per cent or more of them are found to be infected.

In malarious localities the anopheline mosquitoes bite the healthy new-born children and infect many of them.

Such children if not thoroughly treated may remain infected for years. They may become anemic and possess enlarged spleens, and of course may spread the infection to others.

In malarious localities almost every child has been found to contain the parasites of malaria or to possess an enlarged spleen.

In such a locality, therefore, the infection is constantly passed on by means of the mosquitoes from the older children or from adults to the newly born infants, so that the locality may remain malarious for very many years, in fact indefinitely.

In the same way a newcomer arriving in such a locality will very probably become infected, especially if he sleeps in an infected house, even for one night, at a time when mosquitoes are flying and biting. A locality is malarious only when it contains persons infected with the parasites, and also sufficient numbers of the proper species of mosquitoes to carry the infection to the healthy persons.

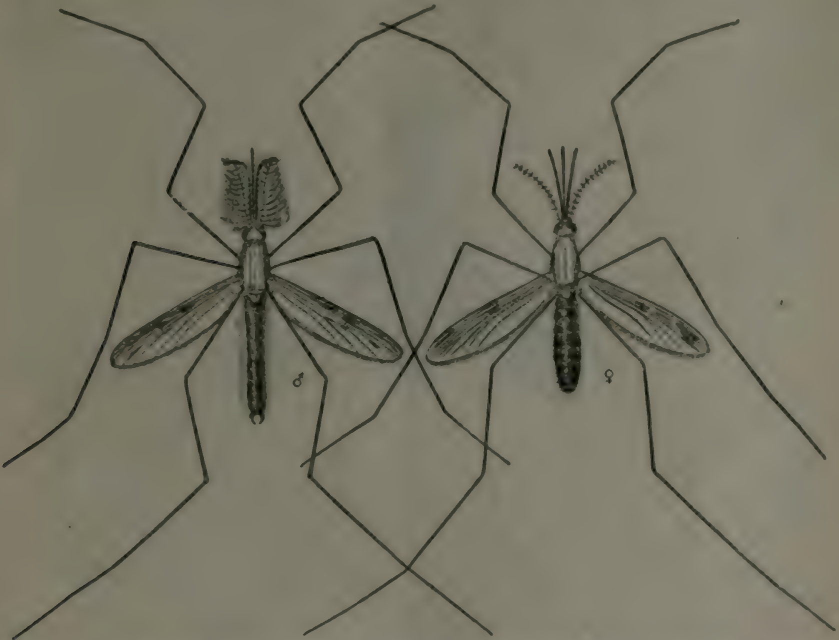

FIG. 1.—*Anopheles quadrimaculatus:* Male and female mosquitoes. Greatly enlarged. (Original.)

THE MALARIAL MOSQUITOES.

There are in the United States only three species of mosquitoes which commonly carry malaria, namely, *Anopheles quadrimaculatus* Say, *Anopheles crucians* Wied., and *Anopheles punctipennis* Say. Several other species of Anopheles are occasionally found, but are not important malarial factors.

Anopheles quadrimaculatus (figs. 1, 4, 5, 6) is commonly found in the more Northern States, and *A. crucians* (fig. 2) more abundantly in the Southern States, particularly in the coastal region.

A. punctipennis (fig. 3) occurs in both Northern and Southern States. It has been found to carry quartan and tertian malaria in the South, but not in the North. A number of experiments have been made with this species in the North, and especially at Baltimore and New York, to see if it will carry malarial parasites, but without success.

The anopheline mosquitoes are distinguished from most other mosquitoes of the United States by the fact that their wings are more or less spotted, and that in resting on the wall their bodies incline away from the wall at an angle, while with most others the body is parallel to the wall. The females also have palpi which are nearly as long as the proboscis, or beak.

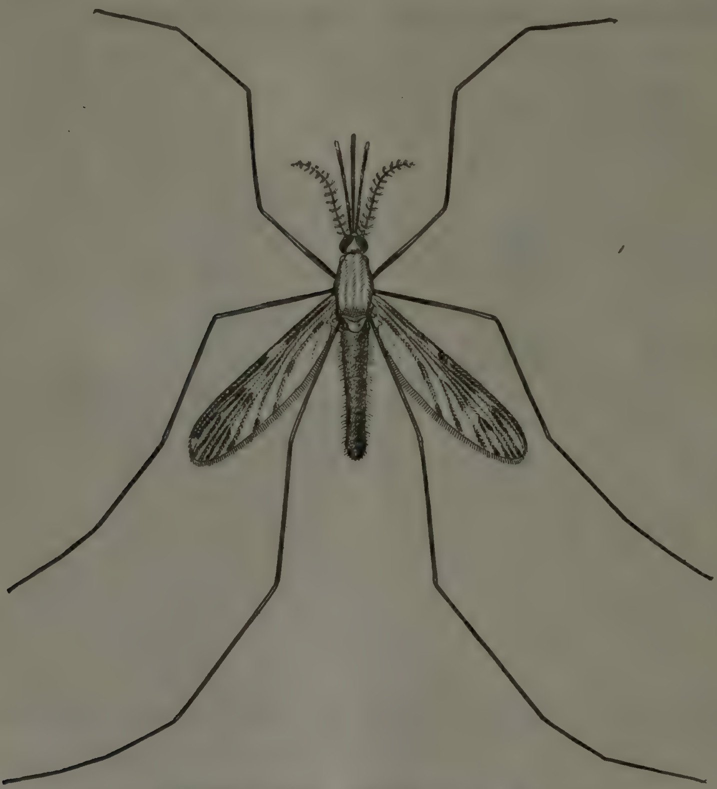

FIG. 2.—*Anopheles crucians:* Female mosquito. Greatly enlarged. (Original.)

The Anopheles mosquitoes above mentioned pass the winter as adults. In the autumn they enter houses, stables, barns, or other outhouses, or seek other sheltered hiding places, and remain there until spring. They are often found in the winter in numbers in the cellars of houses, where they may be killed by fumigation.

These mosquitoes, as a rule, bite only after sundown. *Anopheles crucians* has on rare occasions been known to bite during the day, as has *A. punctipennis.* This has not been recorded of *A. quadrimaculatus.*

They do not fly far. It is doubtful whether any of these species ever flies for more than half a mile.

These Anopheles mosquitoes breed in all sorts of accumulations of standing water, in pools, springs, watering troughs, in the footprints of cattle in marshy land, and in marshes where fish are not abundant, in drains and gutters choked with grass or weeds, in old boats along the waterfronts, in hollows in rocks, in the backwaters of even rapid streams, in earthenware vessels, in water barrels and tubs, in cesspools, and all places carrying water accumulations, whether pure or foul. *Anopheles crucians* and *A. quadrimaculatus* have even been found breeding in brackish water along the seacoast.

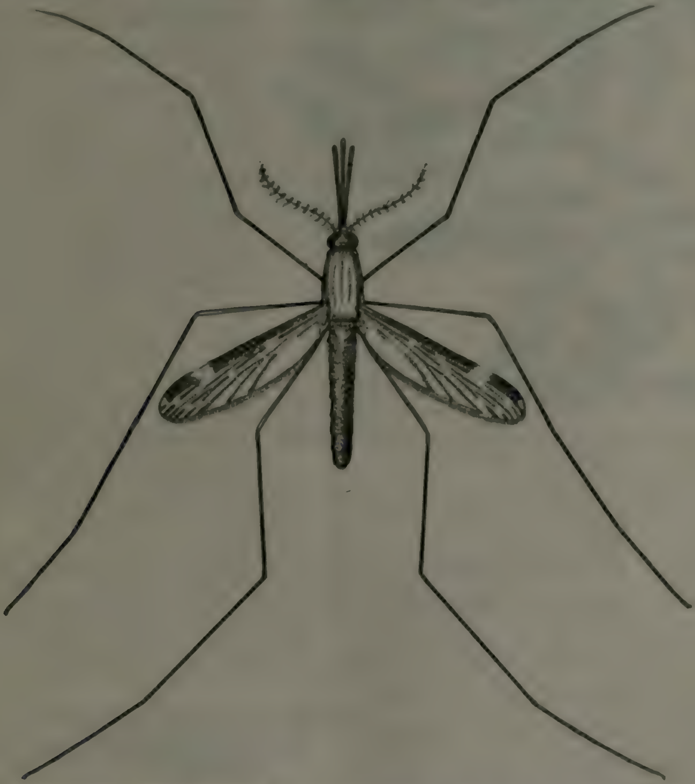

FIG. 3.—*Anopheles punctipennis:* Female mosquito. Greatly enlarged. (Original.)

The minute, blackish eggs (fig. 4) are laid on the surface of the water and are found floating on their sides singly or in groups.

Their larvæ do not hang from the surface of the water by the tail, as do other mosquito larvæ or "wrigglers" when at rest, but lie flat at the surface, with their heads turned upside down, feeding upon minute floating particles at or near the surface (fig. 5).

Their growth is rather rapid, and they may in midsummer reach full size in two weeks after hatching.

When full grown these larvæ transform to pupæ (fig. 6) and remain in this stage at the surface of the water for three or more days, when the adult mosquitoes issue.

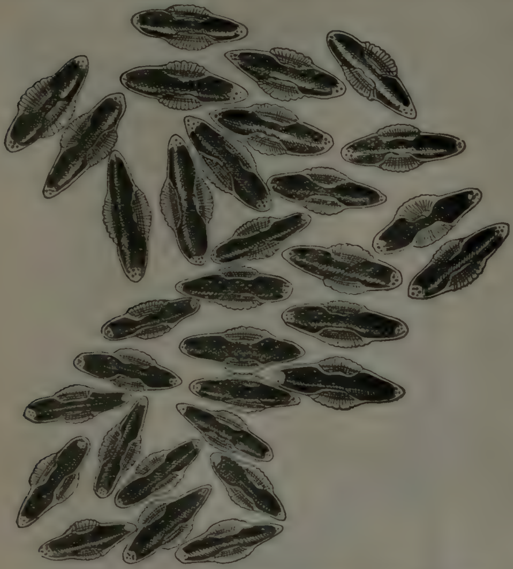

FIG. 4.—*Anopheles quadrimaculatus:* Eggs. Highly magnified. (Original.)

PREVENTION AND CURE.

There are now three recognized means of warfare against malaria: (1) The mechanical protection of individuals from the bites of malarial mosquitoes; (2) the destruction of the Anopheles mosquitoes in any or all of their different stages of growth; (3) the systematic treatment of the population of a malarious locality with quinine until the malaria has been stamped out and there are none of the parasites which cause this disease for the Anopheles mosquitoes to carry.

The first of these methods is largely a matter of personal prevention, and consists in thoroughly screening all habitations of human beings and, in the summer time, of wearing veils and gloves when out of doors after sundown. This method was systematically enforced at the stations on the Italian railroads some years since and resulted in a very great reduction in the malaria rate.

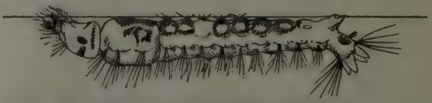

FIG. 5.—*Anopheles quadrimaculatus:* Larva in resting position. Greatly enlarged. (Original.)

The second measure, that of destroying the Anopheles, has been practiced with admirable success in Cuba, in Panama, in West Africa, in Egypt, and in certain localities in India. The measures of mosquito destruction used in these localities and elsewhere are described in a companion Farmers' Bulletin (No. 444).

The quininization method, or cinchonization method as it is called by the Germans and the Italians, has been used by the Germans in East Africa and by the Italians and, to some extent, by the English in India. In Italy, by the means of mechanical protection, the malaria rate was reduced from 65 or 70 per cent down to 14 per cent, but here it held. The quininization method was then introduced, and the general malaria rate for Italy has by its means been reduced to less than 4 per cent.

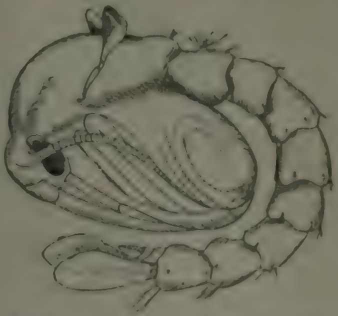

FIG. 6.—*Anopheles quadrimaculatus.* Pupa. Greatly enlarged. (Original.)

This method consists in the distribution of free quinine to all laborers and to the poor living in malarious localities. The quinine is prepared in its most agreeable form, as confectionery and principally as chocolates, the latter containing tannate of quinine, which is not so bitter. It is more easy to induce children and those adults who can not tolerate the ordinary quinine salts to take the quinine in this form.

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